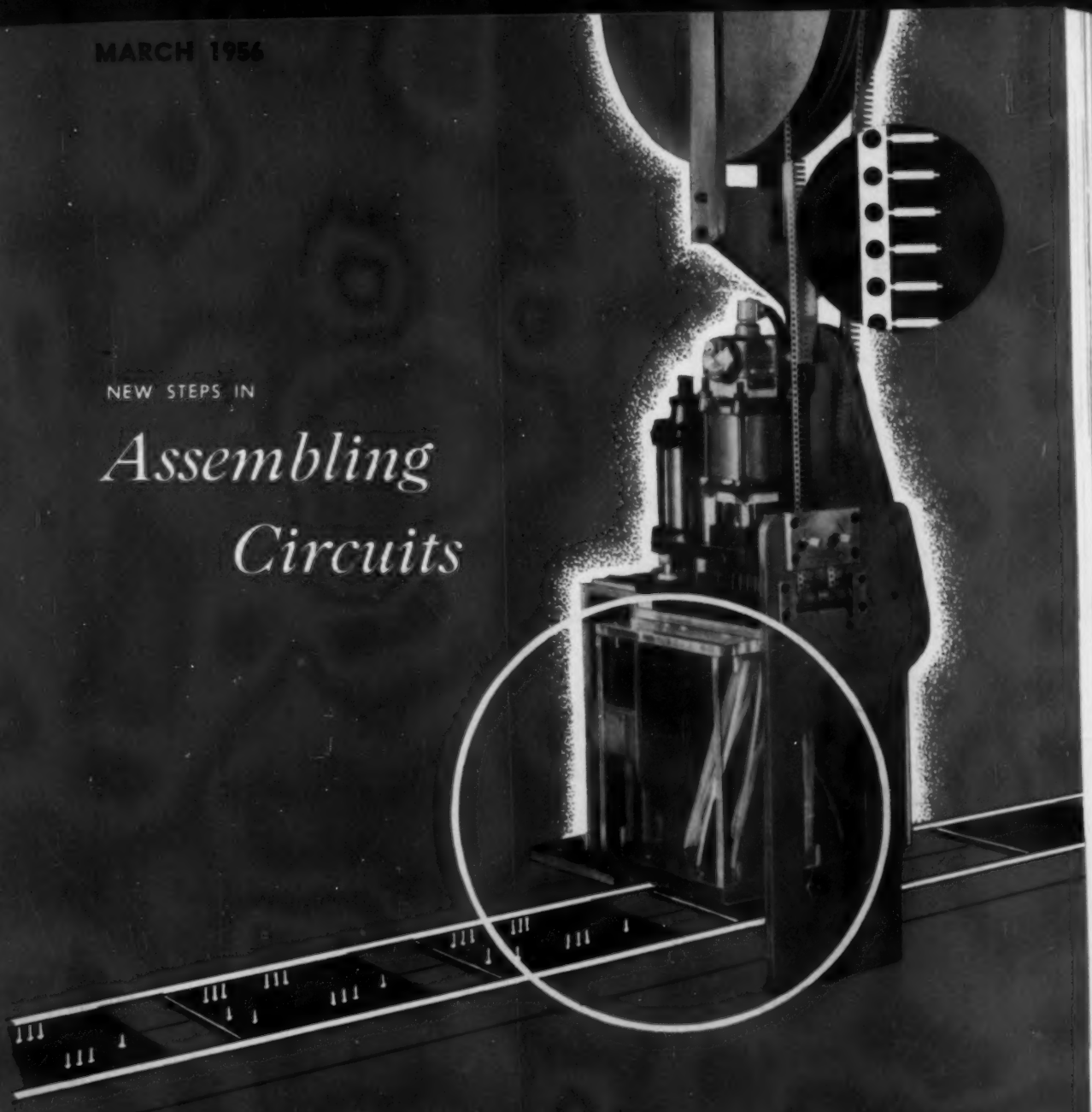
AUTOMATION

MARCH 1956

NEW STEPS IN

Assembling Circuits



The Magazine of Automatic Operations

- Continuous Gaging in Steel Mills
- Transfer Feeding Stampings
- Economics of Automation
- Planning an Automated Plant

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A PENTON PUBLICATION

WEAN "AUTOMATED" TRANS-CAR LINE SOLVES HEAVY PARTS HANDLING PROBLEM

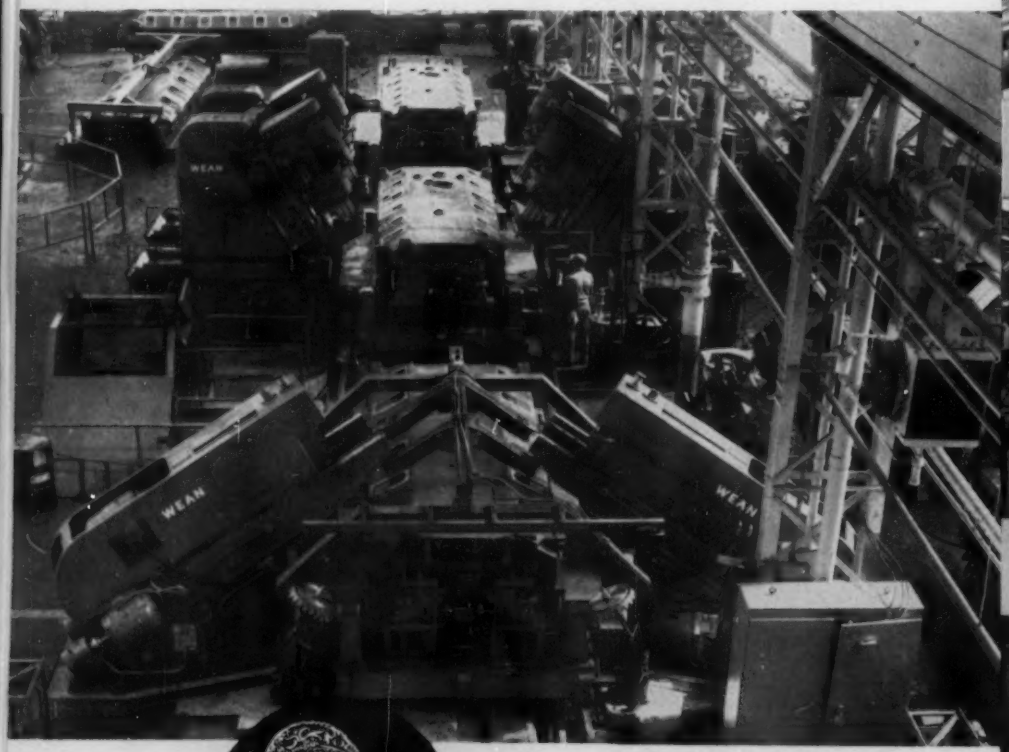
Unique system carries bulky sections through entire machining o eration

The Massey-Harris Co. is used to handling and precision working large machine components. Thus, when they accepted the contract to produce combat vehicle hulls for the Army they immediately got in touch with Wean Equipment engineers.

A team of Wean Equipment engineers working with a similar group from Massey-Harris soon vetoed the possibility of using standard machine tools on a cost basis. It was decided a complete line, especially built to do the job, was the only practical answer.

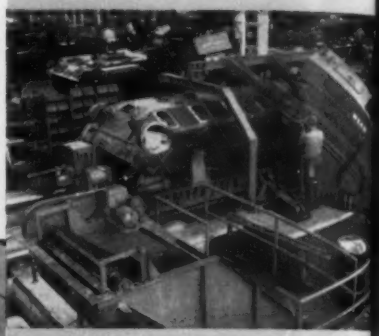
In eight months' time, Wean Equipment developed and built the now famous trans-car line. The line is composed of three stations: milling, drilling, and boring. The unusual feature is the car that operates on a set of tracks, running between stations, and eliminates all handling of the bulky, heavy hull.

If special "automated" machinery is what you're looking for, call in a Wean Equipment man today. He represents probably the widest experience in specialized machinery to be found anywhere. Like Massey-Harris, you'll find Wean the surest, most inexpensive way to soundly engineered, result-getting machinery.

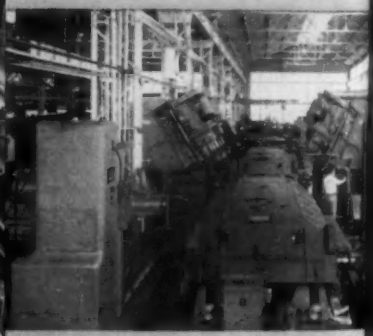


Over-all view of Wean Line that effected tremendous savings in producing giant hulls.

Unique trans-car that carries hull f station to station.



Milling operation. Dry cutting carbide cutters. Air jets remove c



Drilling operation. Beneath the fl coolant system with magnetic separator.

Boring operation. Drills, tap reamers are of high speed ste operations are automatic.

Wean

EQUIPMENT CORPORATION
CLEVELAND, OHIO

MARCH, 1956
Vol. 3—No. 3

AUTOMATION

THE MAGAZINE OF AUTOMATIC OPERATIONS

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automation outlook

THE ONE BEING WATCHED

". . . the great force of automation, with its promise of sweeping changes, brings with it some important problems for the industrial supervisor. The biggest of these is the question of how automation will affect the pattern of supervision. It may seem obvious that the introduction of automation will produce a general reduction of the need for supervision. But persistent effort to think the problem through shows that this belief is the result of a logical fallacy, of stressing one effect of the assumed change and leaving out others.

To the modern foreman, there is nothing mysterious about production. It results from material, men and machinery; natural resources, human energy and tools. Our chances for adjusting the three factors of production to their new loads are far from hopeless. Many of us, who read an article or attend a lecture on automation, often return to our jobs with a feeling that our own company has not kept pace with the march of progress. A new, magic word has been unfolded before our eyes, but we seem powerless to become a part of it because our companies have been slow in taking on the "New Look."

Before a good look can be had at the factors involved in automation, it is necessary to clear away misunderstandings which we believe to be some narrow thinking on this subject by many people. It is this writer's belief that a lavish accumulation of expensive machinery will not of itself increase the productive efficiency of a plant. The glamour of such equipment and the claims made for it often present a tempting proposition, but it pays dividends only when the size of the plant is sufficient to warrant the purchase and insure its continuous use. We further believe that a small producer has many advantages which overmechanization tends to destroy.

We must admit that mass production has done much to wear away the professional status of the foreman. Nor has management's attitude always helped his status. However, we also believe that if we were to remove the challenges and the demands for efficiency and excellence that competition presents to all of us, we would become placid and eventually be faced with much greater problems.

What can I as a foreman do to keep pace with an industrial world that is changing at an ever increasing pace? Few questions are as challenging as this one, and here is our attempt at an answer.

Fortunately for the cause of management, it is only as an individual that you or I can do anything at all. And that is where you as an individual can respond with imagination and efficiency. Clearly the foundation for the long pull ahead into a successful future in the "automation era" must be laid on the broad base of professional competence. The belief that we can hope to succeed through some measure of specialization and narrow concentration is simply not true. The problem of staying with our jobs, and trying to anticipate the penetration of automation to some extent, is basically a problem of competition. The constructive course is to welcome the expanding opportunities now being provided and be sure that we are prepared to take advantage of the situation as it affects our own companies. Perhaps the best way to meet competition is to be the maker of it. If, instead of watching the other fellow for the first move, you can be the one being watched. . ." *Lou Rosenthal, editor, Observer, publication of the Foremen's Club of Greater Cleveland.*

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BPA

AUTOMATION news

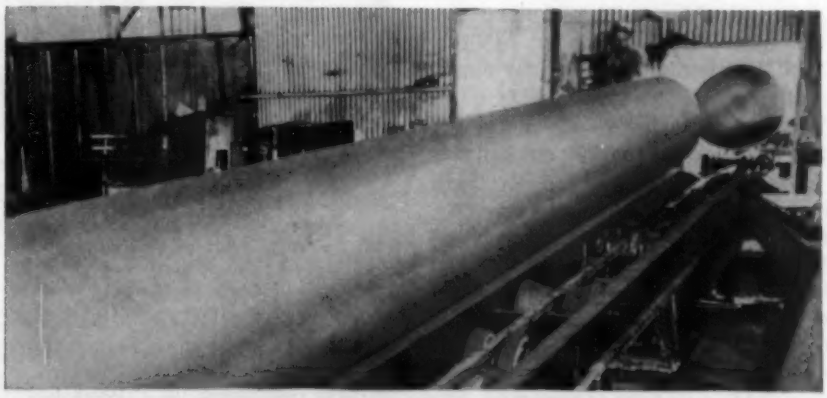
Today's events and developments in the field of automation

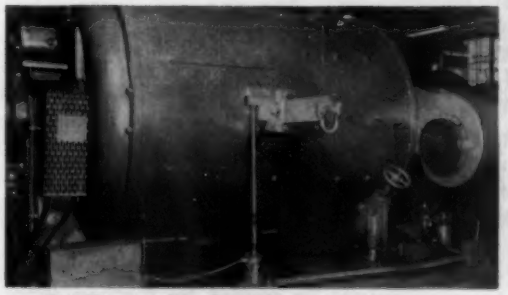
Versatility of Application Stimulates Load Cell Use

SPEED, convenience and accuracy are factors which continue to influence the use of electromechanical devices in weighing operations. Load cells developed by the Baldwin-Lima-Hamilton Corp. are important components in modern improvements to the material handling and weighing field. Following are some of the more recent examples of the use of these components.

Illustrating the consideration of speed in weighing is an application in a plant of the American Bridge Div., United States Steel Corp. Electronic scales built directly into a pipe conveyor consist of four load cells enclosed under each of two cross bars. In weighing operation, the cross bars are lowered hydraulically until the pipe is supported by the load cells and weight is read directly on an indicator near a control point. After the weight and length of a pipe has been recorded, the pipe proceeds on the conveyor. The entire operation requires less than a minute.

The Timken-Detroit Axle Div., Rockwell Spring & Axle Co., has adopted load cells in measuring and controlling the torque of a dc input dynamometer used in tests that simulate typical runs of automotive driving axles in various traffic conditions. The test to be conducted is tape recorded and automatically cycled in the torque device. Located at a fixed distance from the center of the rotating device, load cells respond to both compression and tension and are used to transmit signals to an indicator, calibrated in lb-ft, located at the control point.





THREE examples of weighing and measuring uses of load cells produced by the Baldwin-Lima-Hamilton Corp. are shown. Large steel pipe on a conveyor is lowered onto supports containing load cells and the weight reading is noted by operator at the rear. In second case, torque is measured by application involving a load cell located at fixed distance from shaft center of a dynamometer. In a process application, three cells under an I-beam frame support a tank in a proportioning operation involving liquid sugar. The weight sensing of the cells automatically shuts off a flow of dry sugar and water when the desired proportions of each have been reached.

Automatic shutoff of control valves after a predetermined weight has been signaled by load cells is a feature of an application at a plant of the Union Sugar Div., Consolidated Foods Corp. The plant produces liquid sugar to serve industrial canners. A 2500-gal mixing and 10,000-gal storage tank are gaged by an electronic weighing system in proportioning dry sugar and water and measuring liquid sugar. Each tank stands on a triangular frame of I-beams, the corners of which rest on three load cells. An indicator totalizes the weights indicated by the three load cells and gives direct readings of the tanks in pounds.

The principle of these systems is based on the Baldwin SR-4 bonded resistance wire strain gage which consists of a fine wire grid bonded to a steel supporting member. This grid is slightly strained under load, and its electrical resistance is changed. A matched set of four gages, connected as a Wheatstone bridge in the load cell, is unbalanced by the changes and

produces a voltage proportional to the force supplied to the cell.

TV Over Telephone Lines

PHOTOGRAPHS, printed material and signatures have been transmitted over ordinary telephone lines in the demonstration of an industrial television system which operates without microwave or coaxial cables. The demonstration was staged jointly by the Bell Telephone Co. of Pennsylvania and Dage Television, Div. of Thompson Products Inc., manufacturer of industrial TV equipment.

The new TV system is to be used experimentally for signature verification by a Philadelphia bank. In addition to the banking field, it is anticipated that the equipment may find use in communications between outlying industrial plants and center city offices, transportation and warehouse installations, chain stores, hospitals, police stations and other government offices.

The new unit as presently developed employs a slow scan transmitter which completes the picture on the screen within two to four seconds. The monitor and receiver use tubes which hold the slowly transmitted image long enough for it to be clearly read or photographed.

ELECTRONIC converter which is capable of translating international Morse code signals and converting them automatically to printed page copy on a standard teletypewriter printer has been developed by C G S Laboratories of Stamford, Conn.

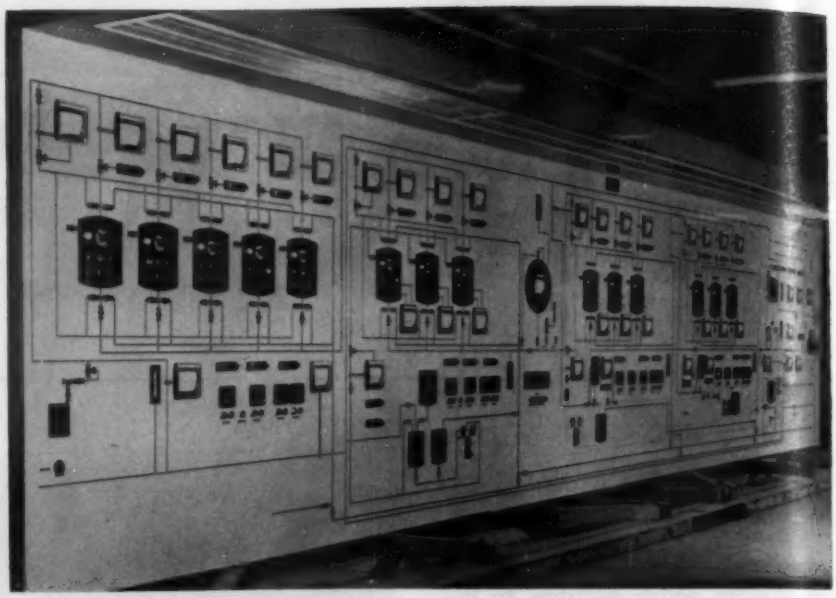
Interpret Automation By Facts —Not Predictions

FORMAL observance of the 250th anniversary of Benjamin Franklin's birth by the Poor Richard Club included a presentation of the gold medal of achievement to **Vice President Richard M. Nixon.**

In his speech following acceptance of the award, Nixon made several comments on automation—appropriate because of Benjamin Franklin's well known interest in labor saving devices. In interpreting modern times as Franklin might have, the Vice President pointed out that so far as automation is concerned, salient facts should be emphasized and not gloomy predictions as to unemployment and dislocation which might be caused by further automation.

Among the facts—there has been no significant rise in unemployment in these days when automation is increasing; there is no appreciable unemployment in those industries in which automation is furthest advanced, namely the chemical, the electrical, communications, and automobile industries; and predictions indicate that our labor force which is presently 42 per cent of our population will be less than 38 per cent in 1965.

The Vice President said, "This brings us to an inevitable conclusion. The only way to make up this growing difference between the relative number of workers and consumers is by better management of the nation's productive resources. It will not be enough to go on doing as well as we have been. We will have to do much better, and that means we will have to have much more automation."



FULLY AUTOMATIC demineralization plant has been designed and built by the Belco Div. of Bogue Electric Mfg. Co., for the Monsanto Chemical Co. plant at Texas City, Tex. The control panel for the new plant is 33 feet long and weighs 5 tons. Designed for accessibility and easy inspection by the operator, the panel shows at a glance the flow pattern in any portion of the plant by means of a lighted flow diagram made up of flat plastic strips, each colored for a particular type of flow. The front of the control panel is covered with Formica, adding to greater attractiveness and ease of maintenance.

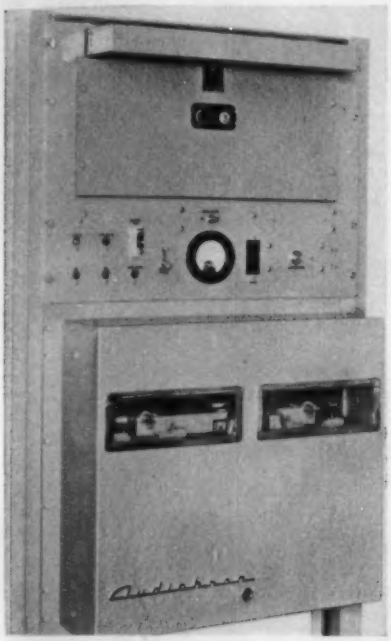
Humidity Measuring Element

DEVELOPED and proved after five years of research, an electrical humidity sensing element has been announced by El-Tronics Inc., producers of nucleonic and electronic equipment.

The element accurately measures relative humidity under almost any conditions and temperatures by employing a conducting plastic whose resistance changes according to the amount of moisture to which it is exposed. Various tests have confirmed the unit's rapid reaction time, its immunity from variations caused by temperture changes, and its reliability when used at high temperatures.

Potential uses of the humidity element cut across many fields. Among the possible uses is control of a drying operation based upon direct measurement of the humidity of the item to be dried. Combined with temperature control, accurate humidity control will answer problems in the air

conditioning field involving damp-cool conditions. Other uses include judging the water condensation within gas pipe lines, direct and accurate measurement of humidity conditions within soil, measuring water content of a wide range of stored goods such as tobacco, etc., and humidity control of large refrigerators used by meat packers.



TIME announcement services provided by various telephone companies has progressed from the point at which a single telephone operator announced the correct time as read from a regulated clock to a modern automatic time-announcement machine which is capable of bringing around-the-clock time services to smaller cities. The Audichron Co., Atlanta, Ga., pioneered in the development of such automatic time-announcement machines and has recently introduced a new unit which uses magnetic recordings to replace the sound-on-film technique formerly employed. The unit contains three drums which are driven by precisely controlled power supply. One drum is used to reproduce any one of twelve different pre-recorded messages as a preamble to the time message. The other two drums carry the hours and the minutes recordings and are arranged to move into the proper register with the passage of time.

Formerly manager of the International Business Machines Corp. Technical Services Laboratory at Poughkeepsie, N. Y., **Walter A. Stadtler** has been appointed director of manufacturing engineering for the corporation. Stadtler has been associated with IBM for nineteen years.

In the Field of Research . . .

Union Switch & Signal Div., Westinghouse Air Brake Co. has demonstrated the feasibility of remote control of a passenger train from a wayside station. Control commands from the wayside station were transmitted to the locomotive through an inductive coupling between a line of wire parallel to the track and a receiving coil mounted on the locomotive.

Designers for Industry Inc., research and development firm specializing in electronics, has moved into new quarters in Cleveland. Among latest projects of the concern is an automated automotive-crankshaft grinder-loader developed for Landis Tool Co. Archer W. Richards is general manager and board chairman of the firm.

Crown Cork & Seal Co. Inc. anticipates early development of non-refrigerated aerosols for semisolid foods, according to W. Earl Graham, research manager. Aseptic canning and pressure packaging advances are key to eventual availability of food aerosols for salad dressings, condiments and sauces normally requiring refrigeration.

Shock & Vibration Research Inc. is name of new Detroit firm headed by R. L. McKay, president. Field of endeavor will range from packaging for safe shipment through detection instruments, telemetering, and systems reliability to electromechanical controls and related types of research. Preparation of research proposal for specific problems is on a "no-cost" basis.

Westinghouse Electric Corp. has reported improved transistor performance with new method of manufacture. Laboratory efforts have produced transistors which handle frequencies encountered in high frequency electronic equipment, and transistors which are unusually sensitive to light yet require low voltage operation. New manufacturing method is not as dependent on exact temperature control and thus quality repeatability factor in manufacturing is improved.

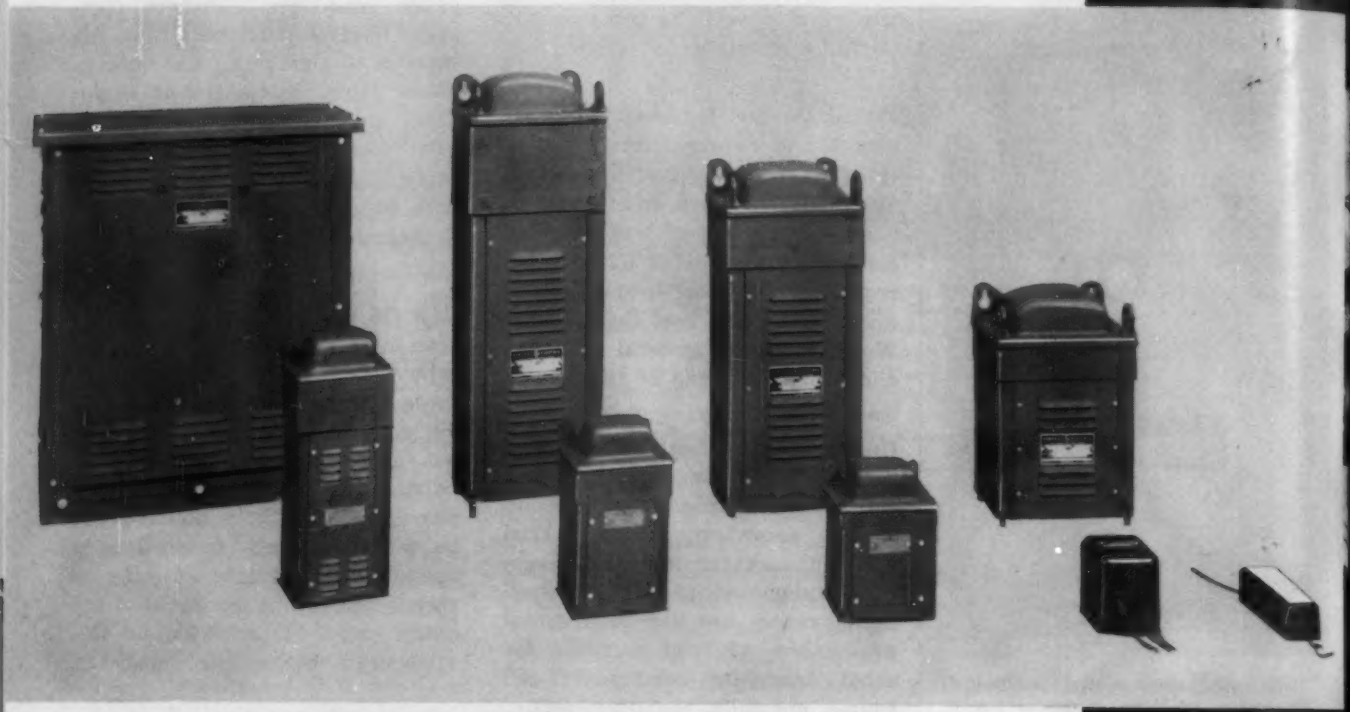
United States Dept. of Commerce has released report of research investigations by U. S. Signal Corps into development of metallized paper capacitors. Project compared electrode materials (zinc far superior to aluminum) and impregnants (solid hydrocarbons best). Tests indicated temperature characteristics of metallized capacitors equivalent to foil capacitors. Report is available from Office of Technical Services.

Gulf Oil Corp. uses new technique (gas-liquid partition chromatography) in research stills to separate gases and liquids whose boiling points are so close that previous methods were inadequate to handle. With the technique, various compounds in a mixture can be made to move forward in a specially treated tube at different speeds and can be separated at the outlet end. Fisher Scientific Co., Pittsburgh, makes the apparatus.

Armour Research Foundation expects annual expenditures of industry and government for scientific research and development to increase by 50 per cent during the coming decade. Basis of forecast is continuing relationship between gross national product and research expenditures (presently 1.1 per cent). If anything, forecast is conservative because of added incentives for scientific and industrial development in such fields as automation and atomic energy.

Fansteel Metallurgical Corp. will in the future produce a solid tantalum capacitor especially designed for use in transistor circuits. The capacitors operate more satisfactorily at high frequencies than conventional capacitors employing liquid or paste electrolytes. Favorable characteristics in range of −70C to 85C have been proved in laboratory tests.

WHEN YOU PLAN
ANY AUTOMATIC PROCESS . . .



COMPLETE SELECTION of G-E voltage stabilizing transformers is available for precise voltage regulation of any control circuit. Smaller and lighter than previous models, they're offered in standard ratings ranging from 15 VA to 10,000 VA.

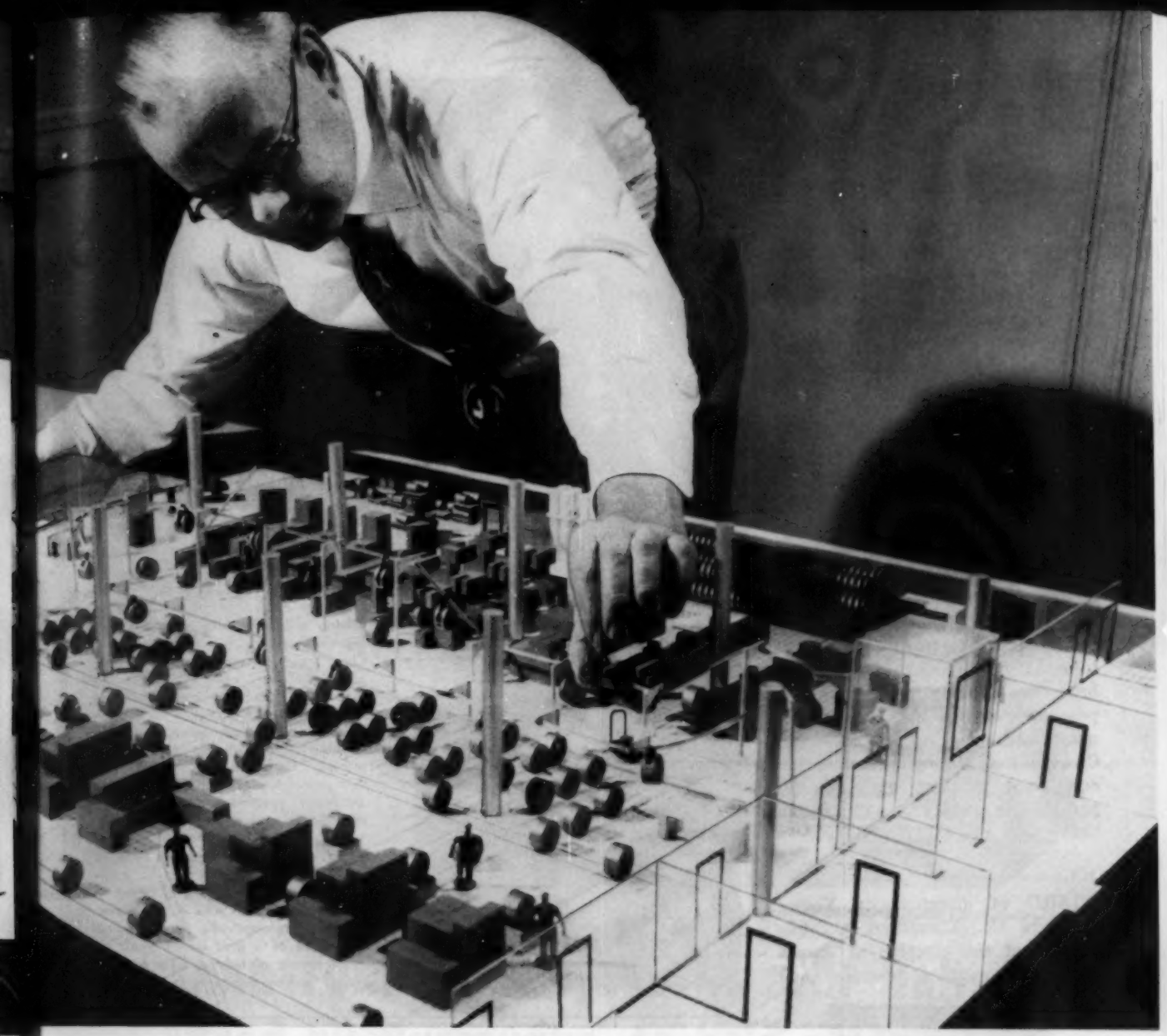
Specify G-E voltage stabilizing transformers

You can lose many hours of production time when line voltage disturbances cause control relays to drop out and shut down automatic production lines. Lightning, for example, can drop line voltage as low as 30% of normal; even if this condition lasts no longer than 20 cycles, the relays may drop out.

With G-E voltage stabilizing transformers in the circuit, control voltage is held to a level high enough to keep the relays locked in. With full load applied, these transformers will stabilize a 30% voltage fluctuation to within ± 1% nominal in less than 1½ cycles.

G-E voltage stabilizing transformers provide simple maintenance. There are no liquids to change, no filters to inspect, and no moving parts. They're easy to install, or to move to other locations when plant requirements change.

Any time you have an operation where continuous production is important, specify G-E voltage stabilizing transformers. Your nearest G-E Apparatus Sales Office will be glad to give you more information, or send in the coupon at right.



to avoid down-time due to voltage fluctuation

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Complete information on these smaller, more efficient units

GEA-5754B—G-E Voltage Stabilizing Transformers contain features, applications, ratings, performance data

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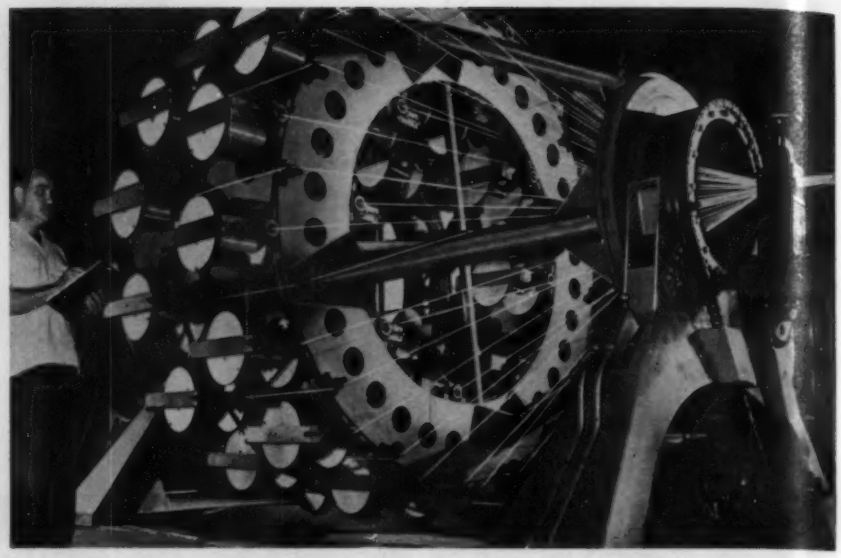
Machine Assembly Expanding

BUILDERS of special automated machines form the most dynamic segment of the nation's machine tool industry, according to **R. E. Cross**, executive vice president of the Cross Co. And automation for assembly operations will be the next big forward thrust for special machine tool builders. He reported that today, assembly operations are only duplicating what is being done by hand, but as engineers design more and more for automation, a rapid acceleration of progress should be seen. The situation is comparable to the television industry, which recently has made a start in redesigning components of receiving sets to conform to automated production. With other industries shifting to the same approach, it means that automation must advance. As an estimate, Cross stated that the automation equipment industry grew by 10 per cent in 1955 and will expand that much more again in 1956.

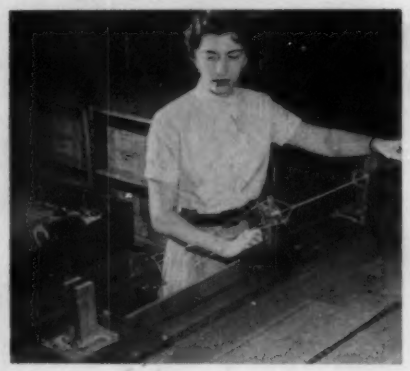
BOARD of directors of Young Brothers Co., Cleveland, O., has announced the election of **James D. Russell** as vice president and

general manager. Russell was formerly a professor of organic chemistry and the head of the chemistry department at a midwestern college, and is a member of the American Chemical Society.

Young Brothers Co. designs and builds a complete line of standard and specially engineered ovens for industrial applications. These include both batch and conveyor types for processes such as metal decorating; aluminum and magnesium heat treating; glass annealing; baking and drying of organic finishes, electrical insulation, plastics, grinding wheels, chemicals; and other industrial purposes. A recent development is a continuous conveyor type oven utilizing radio frequency energy.



PLANETARY cabler has been built by Douglas Roesch Inc., Los Angeles, to solve the production problem of supplying custom and prototype cable. The use of automatic features introduces flexibility into the fabrication of all types of quality cables despite length of cable needed. The result is a saving in cost and production time.



At the other end of the scale involving preparation of wire, the Ford Instrument Co., Div. of Sperry Rand Corp. has developed a simple, completely automatic wire twisting machine for use in prototype and production electronic assembly work. With minor adjustments, the machine can twist doubles, triples, etc. by employing a rotating head and a friction drag that automatically compensates for the constantly decreasing length of wire and the increased load. The wire is not stretched in the operation.

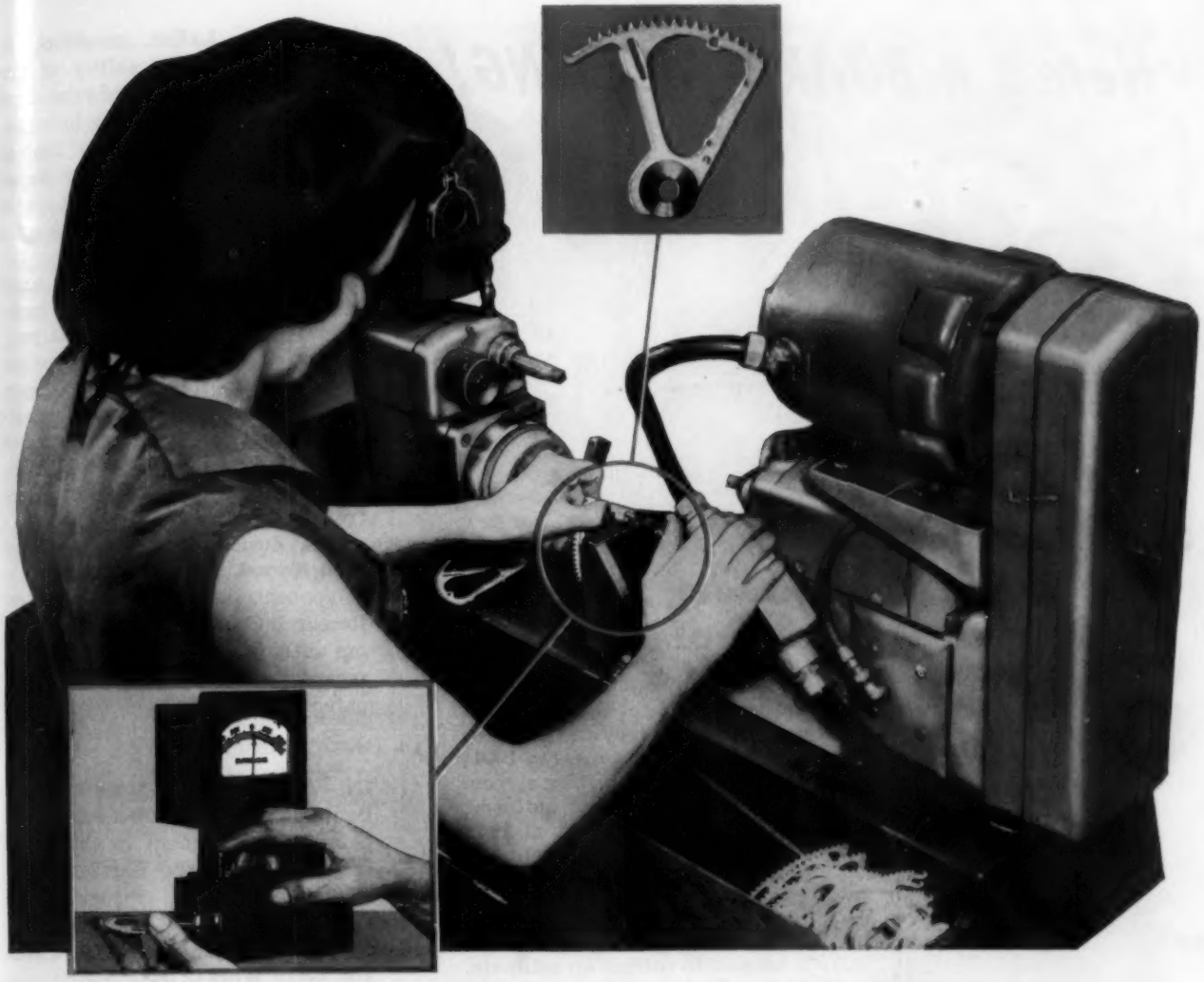
In use, wires are attached to a rotation head which is geared to a dial calibrated in feet. The dial is set for the exact length of wire to be twisted. The unit automatically stops through the action of a limit switch when the exact length of twisted wire with the correct number of turns is completed.

Seamless Aluminum Cans

MASS produced seamless aluminum aerosol containers will soon be available to the packaging field, according to **H. H. Sonnenberg**, chairman of the board of Hunter Douglas Aluminum Corp. The aerosol units will be produced in California and New Jersey plants which are now preparing for production, and it is expected that the initial containers will be on the market during the first half of 1956. Sonnenberg reported that the new packaging unit will have a flexibility of design which will make tooling changes and redesign cost substantially lower. It is also expected that improved four-color printing equipment will result in much cleaner, sharper advertising messages and illustrations than it was previously possible to place on cans.

Magnetic Storage Capacity Doubled By New Recording Head

DEVELOPMENT of a new magnetic recording and playback head capable of handling over four million cycles a second at a tape speed of 20 fps has been announced by



"HARTFORD" Air Hydraulic Drill Units used by Burroughs* to hold precision thickness tolerance

SPOTFACING BOTH SIDES OF A WAFER THIN STEEL GEAR SECTOR TO A THICKNESS TOLERANCE WITHIN .0003" IS ONLY ONE OF THE ADVANTAGES BURROUGHS OBTAINS BY USING HARTFORD DRILL UNITS.

Add up these facts:

1. SPINDLE ACCURACY of units holds parallelism of machined faces.
2. MICROMETER DEPTH CONTROL of Drill Units provides *positive* stop.
3. PRODUCTION DOUBLED over previous method of facing one side at a time. Machining cost cut in half.
4. EXTREME LOW COST of special machine through use of *standard* Hartford components.
5. REJECTS ELIMINATED because the accuracy is *built into the machine.*

*Internationally famous makers of Sensimatic accounting machines.

Another example of better products at lower cost through better methods.

MACHINE TOOL DIVISION F-506-3
THE HARTFORD SPECIAL MACHINERY CO.
285 Homestead Avenue, Hartford 12, Conn.

☐ Have Field Engineer call.
☐ Send Application Data Sheet and descriptive Bulletin.

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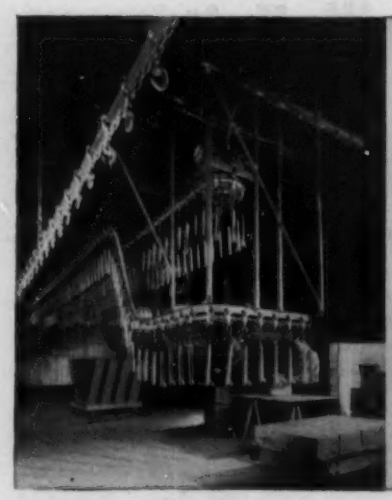

This compact A-F Engineered Conveying System moves shelving brackets from loading station to paint dip tanks (4 movable tanks, side by side, provide 4 easily positioned colors) while other formed parts are carried to spray booth, sprayed, then carried into in-process drying and live storage on inner concentric track loops to be delivered dry and ready for shipment at unloading station. There are many other features of this A-F Engineered installation that may interest you—fully illustrated—as are other installations, some of them fully automatic—in a new 32 page A-F *Engineered* Overhead Trolley Conveyor book.

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William G. Laffer, president of Clevite Corp. The ability of the component to record and reproduce densely stored magnetic information greatly extends the use of magnetic recording in new areas of technology. Nearly 20,000 cycles can be recorded on each inch of a magnetic tape.

Use of the new magnetic head is expected to improve the techniques of recording television programs on magnetic tape rather than on film. It will also more than double the amount of information that can be recorded in the magnetic storage devices which are essential parts of many electronic computers.

The device was developed by **Otto Kornei,** head of the magnetic components section at the Clevite Research Center. Kornei is a leading authority on disk and magnetic recording and holds more than 20 patents in that field.

IN A RECENT announcement **Paul H. Richardson** has been named vice president in charge of engineering for the Hartford Special Machinery Co. Prior to joining Hartford Special, Richardson was general manager of the Paragon Gear Works, Inc.

Instruments Define Color

CONTROLLING interest in Kaye Development Co. Inc., manufacturer of electronic color evaluation instruments and related detection devices, has been acquired by the Atomic Instrument Co., Cambridge, Mass.

The Kaye products provide instantaneous and accurate readings both in the visible color and invisible wave length ranges, from ultraviolet through the infrared. A unit known as a Trichrometer electronically transposes visible color as the eye observes it into absolute numerical terms defining hue, saturation and brightness, which appear immediately as readings on the face of the machine. Another instrument in the Kaye line is a deviation apparatus which instantly detects any change of a chosen wave length set in a given process, whether in the eye-visible, or wider wave length ranges; the instru-

ment signals for corrective action when deviation occurs.

According to **Leonard W. Cronkhite**, president of Atomic Instrument Co., these devices provide for a high degree of speed, simplicity, accuracy and economy in the measurement of color. This method of color evaluation and control does away with the need of mathematical calculations, thereby completely eliminating the time previously required for color study programs. It is expected that these instruments will open new possibilities for automatic process correction and control in the chemical, oil, tile, paint, rubber, textile, and other fields of flow and piece processing involving color or shade, or in situations where wave length (frequency) serves as a guiding factor.

DESIGNERS and manufacturers of automated materials handling controls and equipment, Dasol Corp., has moved its offices and laboratory from 118 East 28th Street to larger quarters at 14 Charlton Street, New York, N. Y.

MEETINGS AND EVENTS

Mar. 14-15—

American Society of Mechanical Engineers. Engineering Management Conference to be held Hotel Statler, St. Louis, Mo. Additional information may be obtained from Society Headquarters, 29 West 39th St., New York, N. Y.

Mar. 19-21—

Society of Automotive Engineers. National Production Meeting and Forums to be held Hotel Statler, Cleveland, O. Additional information may be obtained from Society Headquarters, 29 West 39th St., New York 18, N. Y.

Mar. 19-22—

Institute of Radio Engineers. National Convention to be held Waldorf-Astoria Hotel and Kingsbridge Armory, New York. Additional information may be obtained from Society Headquarters, 1 East 79th St., New York, N. Y.

Mar. 19-23—

American Society of Tool Engi-

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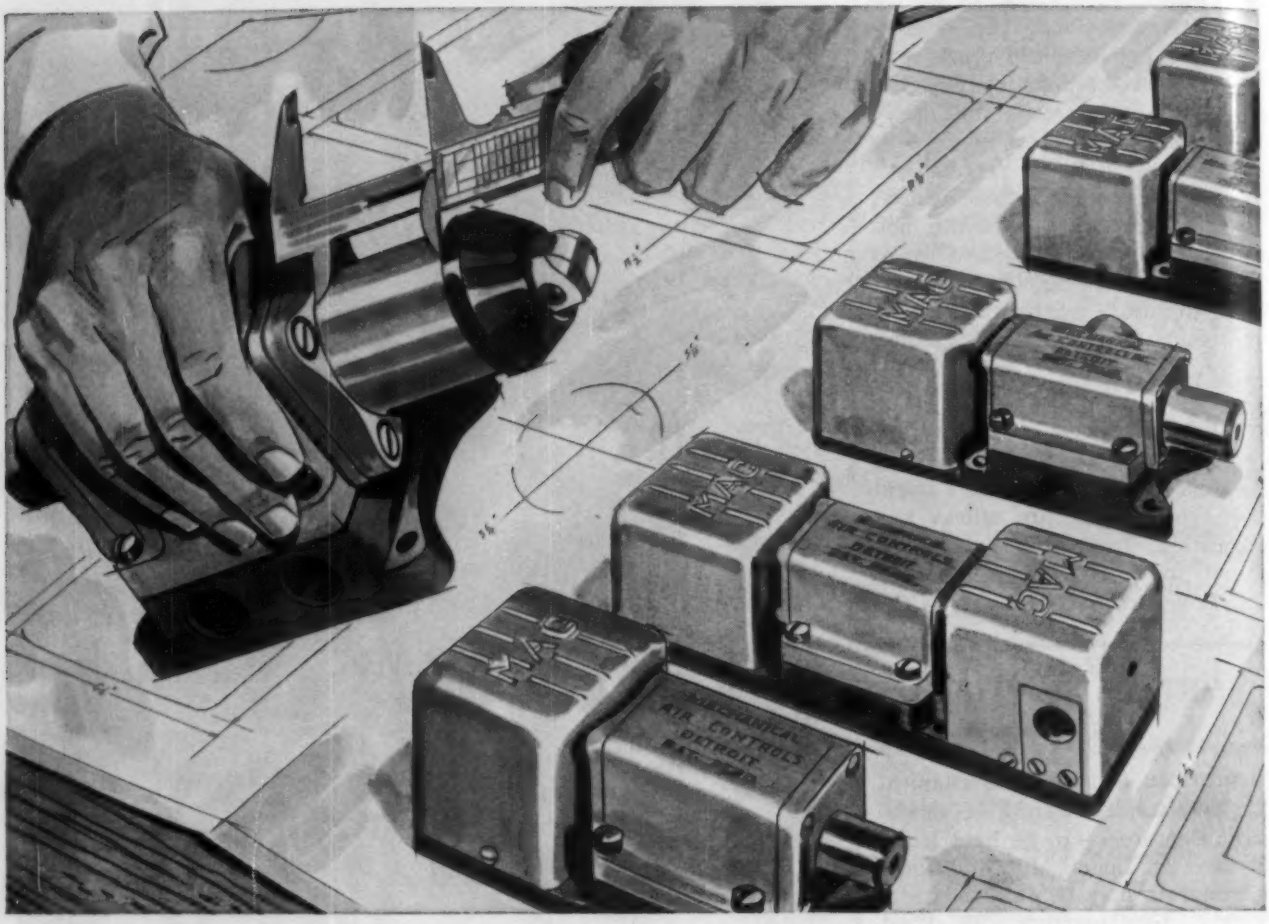

If you walked into our plant you'd hear the rhythm of air valves . . . see machines and men—*just testing!* They're the "fault-finders"—methodically inspecting each MAC valve . . . checking alignment and bore precision . . . hunting a defect in a spring, a faulty solenoid or an imperfect seal. The slightest flaw brings a quick reject. For at MAC we're building *reputation* as well as valves. We make high quality standard on all 98 models.

You'll find MAC valves outstanding, too, for dependability, performance *and value*. They're lighter, more compact, have fewer parts to wear. MAC's simplified design assures millions of operating cycles — with little, if any, maintenance. Small wonder MAC valves are showing up on more and more equipment at tool shows, in shops and plants, *everywhere*.

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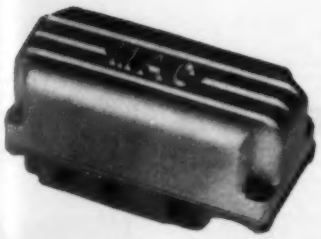

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CHICAGO 43—Mike C. Modrich & Co., 10336 South Western Ave., Hilltop 5-3640

INDIANA
FORT WAYNE 3—Neff Engineering Co., P. O. Box 2001, Station A, 2339 Crescent Ave., EAstbrook 7391
INDIANAPOLIS 20—Neff Engineering Co., P.O. Box 7361, 42nd St. Station, BRoadway 2330
SOUTH BEND—Dick Futter, 103 South Varsity Dr., CEntral 2-4856

MARYLAND
BALTIMORE 6—Grand Air-Hydro Division, K. William Ostrom & Co., Inc., 6105 Alta Ave., HAmilton 6-6669

MASSACHUSETTS (and New England)
BOSTON 34—Electrical Apparatus Co., Inc., 1200 Soldiers Field Rd., STadium 2-7440

MICHIGAN
BAY CITY—Fred Kober, 506 Chilson St., 2-2629
FLINT—Kober Sales Engineering Co., 514 Beach St., CEdar 8-5123
GRAND RAPIDS—Fred McAvoy, 190 Monroe N.W., GLendale 6-1321

MINNESOTA
MINNEAPOLIS 4—Air Engineering & Supply Co., 2445 Nicollet Ave., FEderal 9-5579
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neers. Industrial exposition to be held in conjunction with 24th Annual Convention in International Amphitheatre, Chicago. Additional information may be obtained from Richard Gebers, 10700 Puritan, Detroit 28, Mich.

Mar. 30-31—

University of California. Joint meeting of Western Section of the Operations Research Society of America and Los Angeles Chapter of the Institute of Management Sciences to be held Los Angeles campus. Additional information may be obtained from University of California Extension, Engineering, Los Angeles 24, Calif.

April 9-12—

American Management Association. Twenty-fifth National Packaging Exposition and Conference to be held Convention Hall, Atlantic City, N. J. Additional information may be obtained from Association Headquarters, 330 West 42nd St., New York 36, N. Y.

April 9-22—

International Exhibition Instrumentation - Automation. Jointly sponsored by Norwegian Industries Development Association and Royal Norwegian Council for Scientific and Industrial Research. To be held Oslo, Norway. Additional information may be obtained from secretary of Studieseiskapet for Norsk Industri, Munkedamsvein 53B, Oslo, Norway.

April 10-11—

Midwest Research Institute. Symposium for management on applications of analog computers to be held University of Kansas City. Additional information may be obtained from Midwest Research Institute, 425 Volker Blvd., Kansas City 10, Mo.

April 18-20—

Illinois Institute of Technology. Armour Research Foundation sponsored conference on industrial research to be held on university campus. Additional information may be obtained from Illinois Institute of Technology, 35 West 33rd St., Technology Center, Chicago 16, Ill.

April 26-27—

American Institute of Electrical Engineers. Conference on recording and controlling instruments to be held Bradford Hotel, Boston. Additional information may be obtained from Institute Headquarters, 33 West 39th St., New York 18, N. Y.

May 9-11—

American Material Handling Society. Western Material Handling Show and conference to be held Western Livestock Exhibit Bldg., Los Angeles. Additional information may be obtained from Public Relations Director, 1501 Oregon Ave., Long Beach 13, Calif.

May 9-11—

American Welding Society. Fourth Welding Show and conference to be held Memorial Auditorium, Buffalo, N. Y. Additional information may be obtained from Society Headquarters, 33 West 39th St., New York 18, N. Y.

May 9-19—

Mechanical Handling Exhibition and Convention. To be held Earls Court, London, England. Additional information may be obtained from exhibition manager, Dorset House, Stamford St., London, S.E. 1, England.

May 14-17—

American Society of Mechanical Engineers. Design Engineering show to be held Convention Hall, Philadelphia. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

". . . then, when the computer gives us the answer, this group of engineers here check its accuracy."

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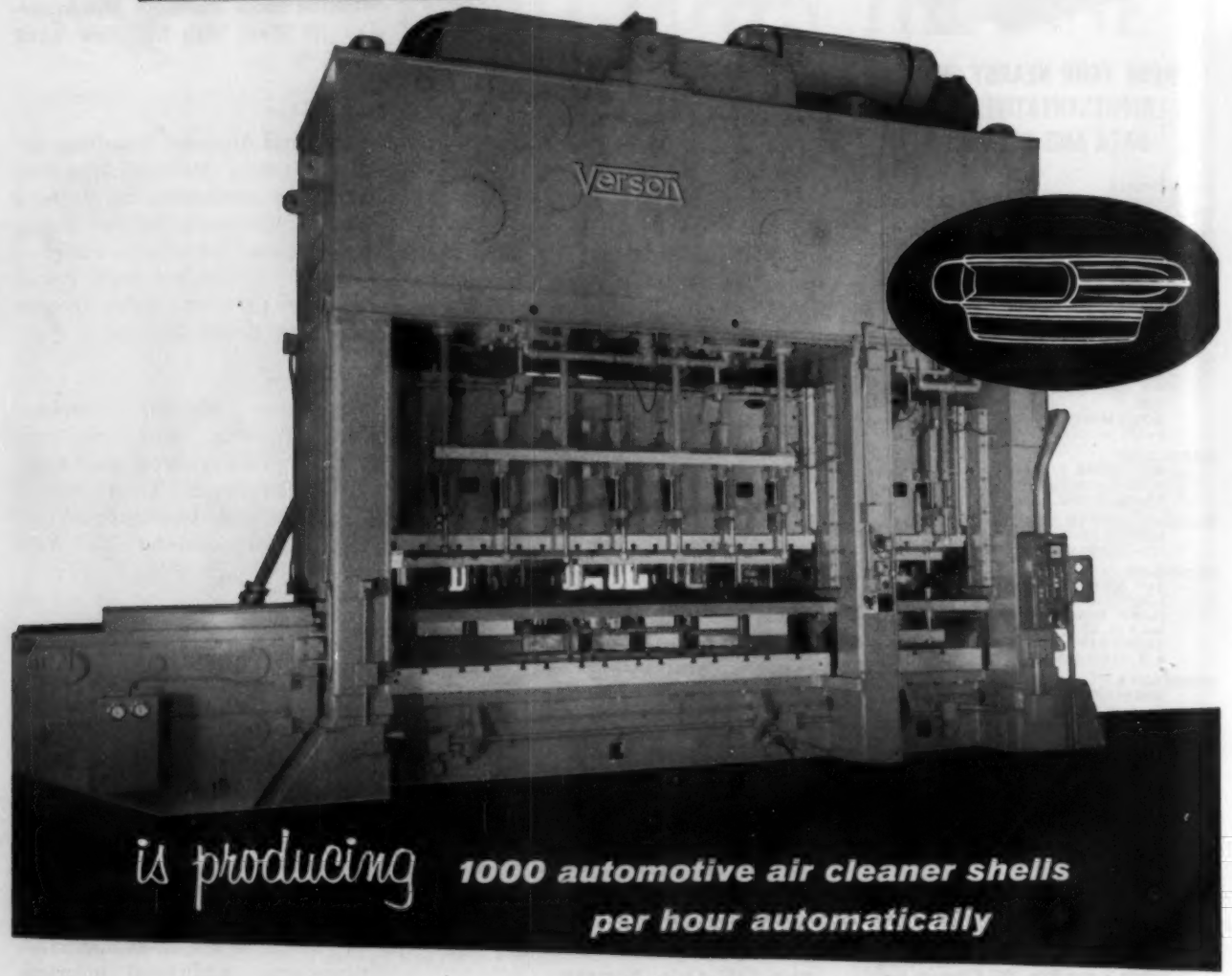

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Verson Transmat Presses offer unusual economy and efficiency whenever four thousand or more pieces, requiring four or more operations, are produced per day. Essentially a single press with multiple die stations and separately adjustable slides, the Transmat transfers the work piece by mechanical fingers synchronized with the press action. Feeding can be from coil stock or blanks. Intermediate handling, pickling or annealing is unnecessary.

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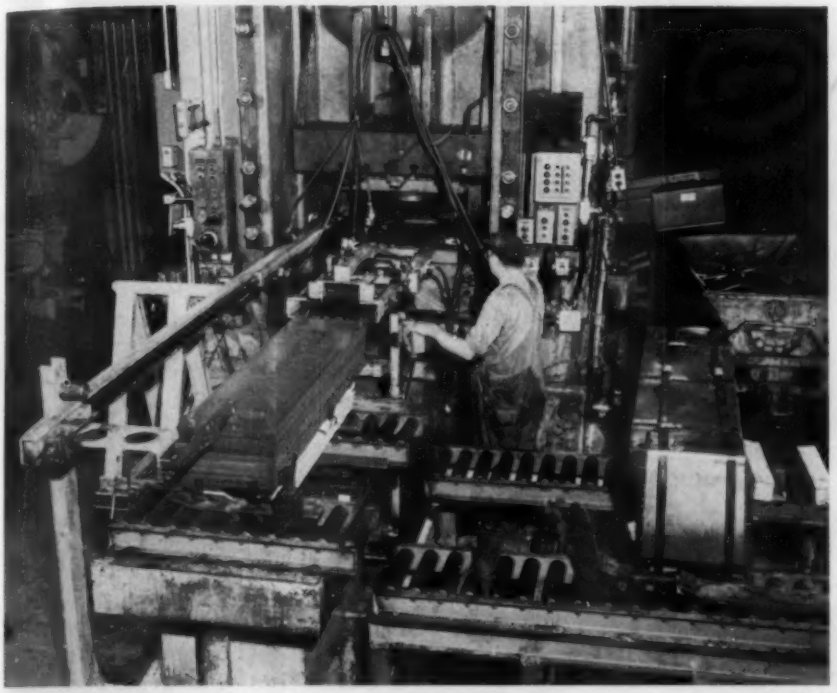
By JAMES C. KEEBLER
Associate Editor



Automatic handling system for heavy sheets removes backbreaking drudgery from the operation of this press at a Buick plant in Flint, Mich.

SAE Has the Word

TECHNICAL societies' program chairmen have come to look upon automation as a friend indeed. Whether he is the eager-beaver type, zealously trying to keep his organization properly informed on the latest trends in industrial development, or the poor duck that got drafted by last year's nominating committee and is eking by with a couple of late-great athletes plugging the holes in this year's schedule — the program chairman becomes the hero of the hour when his session on automation smashes previous records of attendance and enthusiasm.

What's In A Name?

This high level of interest in anything bearing the name automation has been reported by organizations representing all types of specialized industries, from shoes to computers. Associations of management, labor, accounting, purchasing, engineering and so on down the line are purposefully putting automation on the program.

These meetings serve to increase general understanding of the subject but, one trend that is observed all too often at such gatherings is a lapse from constructive thinking into meaningless bickering as to whether this word *automation* is grammatically, technically or morally proper to be used to describe what's going on.

Understandably, a session chairman at an automation program as part of a national society meeting last November expressed his pleasure that the speaker being introduced was an expert on automation. Background for his happiness was an admitted sense of personal frustration at the use of the word. The fond hope was that this expert would make the meaning clear. One machine tool builder insists that the words *continuous cycling* are more descriptive; besides, their company has been using them for nigh onto 65 years.

Another impartial source votes for *continuous production machinery*, and wordmongers have filibustered long and loud for *mechanization, mechamation, productioneering, automatism, automatization* and *cybernetics.*

A Rose By Any Other. . . . .

A Western Electric engineer kept a Baltimore ASME meeting on the straight and narrow by suggesting to the speaker beforehand that his fellow members didn't want to waste time quibbling about what to call it. They wanted to know more about how to do it.

This is significant in the light of the fact that at union contract time Detroit public relations offices have been known to ban the official use of the dirty word because some workers think it is a contraction of *unemployment.* Meanwhile the automation engineering and maintenance crews whose overtime hours are devoted to perfecting the new processes of production are well aware of the increased indirect labor required to evolve the technological advancements necessary to maintain competitive standing.

Other areas of human endeavor have also had skirmishes centering about a play on words. Albert Guerard is quoted as having set the art world straight with his definition, "Art is whatever has been considered art for the longest time by the most people who are supposed to know."

The Art of Automating

So far as automaking automation is concerned, the 1956 SAE annual meeting in Detroit was an assembly of a lot of "people who are supposed to know." SAE Vice President for Production Activity

Paul A. Miller staged an automation session that used a new technique to pass some of this know-how on to the members present.

Top executives in the automobile and aircraft industries became actors in a play in which they were the management of a mythical company whose manufacturing and sales outlooks spelled doom.

The stars included: A. T. Colwell, vice president of Thompson Products, Inc.; L. I. Woolson, president of De Soto; E. N. Cole, chief engineer of Chevrolet; C. L. Hecker, first vice president of Oliver Corp.; F. E. Farrell, assistant director of automotive sales for Bendix Corp.; and Delmar Robertson, vice president in charge of sales of Dana Corp.

Roles portrayed were respectively those of executive vice president, manufacturing manager, project engineer, sales manager, director of purchases, and a vendor.

The program was mapped out to have one rehearsal in the morning to go over the 11-page outline and then go on-stage in the afternoon using the slides and props that had been arranged, but without a prepared script.

Theme of the drama was that in the face of decreasing sales and vanishing profits it was necessary for this company to take steps on a policymaking level that would insure the integration of product improvements and automated manufacturing techniques.

In the first scene the executive vice president held a meeting to orient his department heads with the problems and assign each his area of investigation. In the second scene each reported his findings and a plan of action was devised.

Role of Automation

Automation's role in this play reflects the automakers' thinking on the subject. Some pertinent points were made evident. Other than a definition given by the manufacturing manager to show what the word *automation* meant to their operations there was no question as to meaning. There was no hassle over terminology.

Automation was recognized as the answer to high production costs. The needs for studies of length of runs and extent of tooling costs were seen as initial steps in deciding which lines to automate. Sales department must submit volume forecasts.

Considerations of part design should include an attempt to anticipate future model changes in a manner that will not materially affect basic tooling in the automated process.

Automation programs require close co-ordination between design engineering and manufacturing groups. The company's manufacturing staff works with machinery builders and automation specialists on the modernization activities.

Parts vendors can be used to increased advantage where like features of part design enable them to combine runs of parts for several customers and thus increase volume to the point where more automated production facilities are warranted. This provides the customer with savings in tooling costs as well as in parts price. To effectively achieve such savings the co-operation of the design project engineer, the director of purchases, the prospective vendors and the manufacturing manager is required.

To properly decide whether to buy outside or make a given item yourself requires not only manufacturing cost estimates to compare against vendor's bids, but also analysis of factors such as plant capacity and tooling up time. Management's automation program gets the consideration of the board of directors with regard to company financing. The figures must show a proper per cent return on sales and on the new investment.

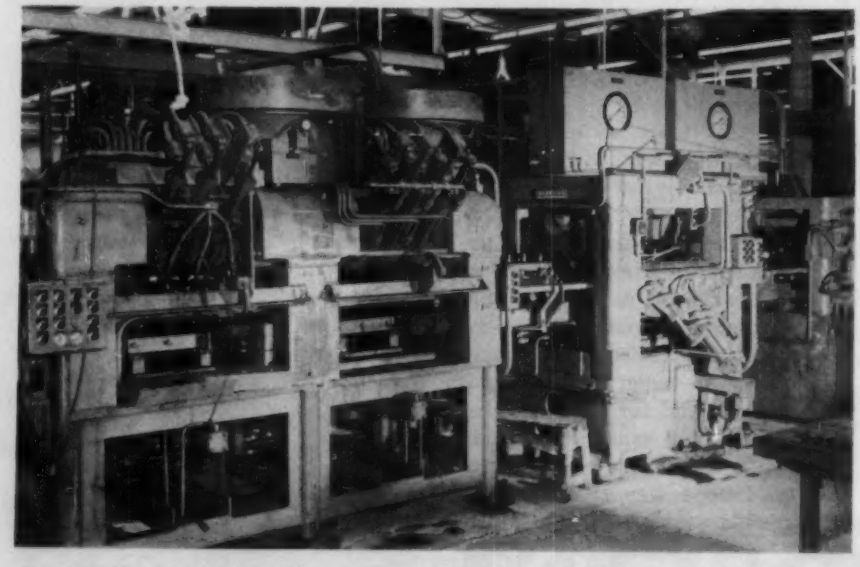
Keep Up-To-Date

These automakers indicate that it is a costly mistake for company management to ignore needed manufacturing plant overhauling—that they would be completely asleep in their jobs if they were to choose to "pile up cash" rather than to redesign and update production equipment.

The long-run health of the business is at stake. If need be, additional capitalization should be acquired by sale of stock. Interim plans to save the day can include immediate automating of a few jobs that fit into the overall scheme of the future program. Immediate funds can be had from bank loans.

Got The Word

It sums up to appear that the automakers have the word, and the word is *automation* in their plans to keep a competitive business alive.



On the V-8 engine block line at Packard's Utica plant, sealer plugs are automatically installed by the Ingersoll machine at left, then blocks are air-tested for leaks at right. After the test, the blocks move to next station where lugs are milled off

See Booth 496 at the ASTE Show

Eli Whitney Never Called It Automation!

In 1794 when Whitney invented an automatic machine, the cotton gin, he hadn't heard about Automation. He invented gages, too, but left it to Federal to invent gages many years later for automatic dimensional control. Even then, nobody talked about Automation.

It doesn't matter what you call the automatic way of working. The important thing is how you meet its challenge. Contrary to commonly held impressions, automatic methods are not alone for the mammoth transfer machine operations of the automotive industry. We know, for we're regularly making successful installations, both large and small, in widely diversified industries. Federal Automatic Gages today are used profitably on a full range of products from refrigerator pistons to railroad car axles.

Our experience goes back long before the word Automation was coined. We work closely and successfully with machine tool builders to provide gages that conform to the capabilities of their machines. Our engineers provide various degrees of control on existing machines in the field and also work in close collaboration with machine designers to provide gaging and control units built into the manufacturers' original machines.

Today many producers are profiting from Federal Automation Gages. They are cashing in on our broad knowledge and most unbiased thinking in the dimensional control field. Federal engineers are widely experienced in the capabilities and limitations of mechanical, air, electric and electronic gages . . . and play no favorites. Their goal is the development of the one best gage for any job, in the fastest time at the lowest cost. Whether it's an air-electric gage that automatically adjusts a machine to prevent out-of-tolerance production, or a conveyor-fed electronic gage that sorts 19,500 pieces an hour, the chances are that the right Federal gage pays for itself in a year. That's really making automation pay! Ask Federal first for recommendations. Write or call us today.

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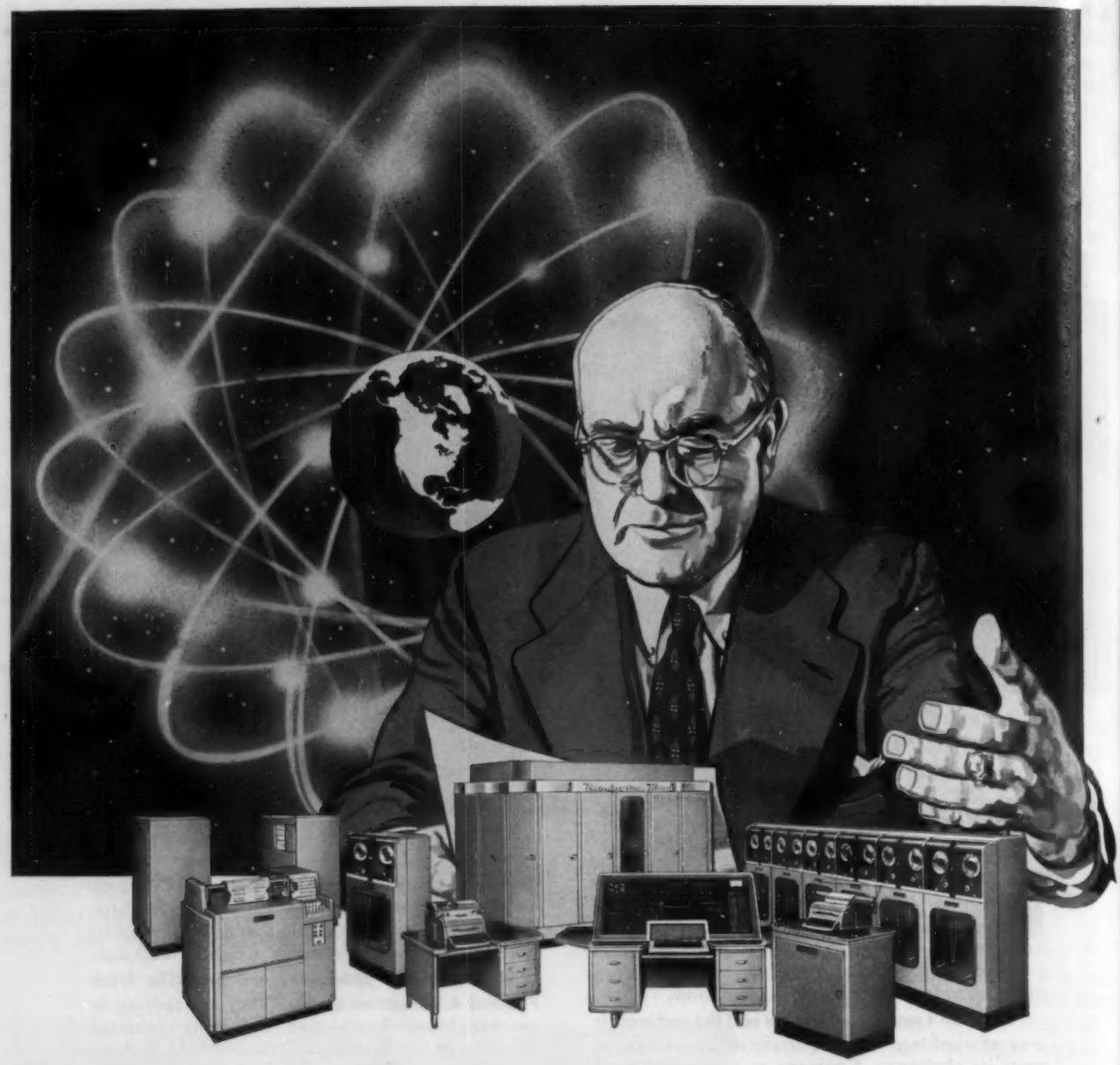

UNIVAC: "You're trying to divide by zero"

A scientist, testing a formula on Univac® recently, was amazed to see the computing system stop, then automatically type the reproof: "You're trying to divide by zero." A quick check proved that Univac, as always, was right.

This graphic demonstration points out just one of many Remington Rand refinements in the art of computer programming and operation. For Univac has been trained to spot human errors. It can now carry out commands given in simple business English. It can even manufacture automatically its own program of instructions – at electronic speeds, with unequalled accuracy.

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The unprecedented savings of Univac data-processing have been proved by solving actual customer problems—not by working out theoretical solutions with non-existent computers. When you install Univac, you're sure to get under way faster, surer, and more economically because the System has already handled similar work.

Univac is now at work in leading organizations throughout the country. And, in today's competitive market, the company which cuts its overhead first comes out on top. So don't wait until 1957 . . . 1958 . . . or 1959 to cash in on the tremendous savings available to you *now* with the Univac System.

Remington Rand Univac

DIVISION OF SPERRY RAND CORPORATION

Organize for Results

Viewed as an engineering and organizational problem, automation can be basically classified or described as horizontal in nature. It is not peculiar to any one industry. It is a fundamental engineering technique that offers equally outstanding results regardless of the area of application. Successful automation requires a blending and co-ordination of know-how from many narrow specialized "vertical" areas of engineering and industry.

For continuous processing systems of any kind, the knowledge and equipment of two or more specialized industrial fields may be required. In the past the conventional approach permitted facilities for each production step to be developed separately. With automation, however, these must be tied carefully into a single system. It is not unusual to find combinations of material handling, chemical processing, heating, mixing, blending, pressing, machining, assembling, inspecting, storing or packaging brought together into unified systems.

The major problem in automation consists in the engineering of integrated production systems involving widely divergent manufacturing know-how in an atmosphere where specialization has been the typical practice. Thus, the need has arisen for developing special automation engineering groups of diversified background and experience. Few groups have been organized on such a basis purposely—each industry as a rule seeks more specialists from within their own area of endeavor.

By organizing engineering groups of wide industrial experience, the production know-how and techniques commonplace in one industry readily can be adapted and transplanted into another. Instances have been all too numerous where one industry has been found to be working diligently to develop a method identical to one in use for many years in another industry. Automation engineering, organized on a broad horizontal basis, can bring to light many of these obscure developments for further practical application. Tremendous benefits await management recognition of the opportunities.

EDITOR

AUTOMATION

ECONOMICS OF AUTOMATION

By A. E. PUUTIO
Industrial Accountant
Richmond, Ind.

Increased application of previously available methods and machines plus new techniques and equipment mark the continuing spread of automation. Reasons for this spread, its problems and results are important to all of us. Highlighted in this discussion of these factors are the effects of automation on accounting systems as well as design, production and general business management.

AUTOMATION CONTINUES gathering momentum. Every large company, as well as most of the smaller ones, are now deeply committed to automation. The tempo increases with each new technological change or improvement. New technologies, in fact, entire new industries, are in the making.

This swing to automation is not confined to manufacturing operations. Clerical and office functions, after a rather slow start, are fast catching up with the tremendous strides already made in the factory. The range of automation is unlimited.

Before we review the reasons for this rush to automate and the benefits to be gained, let us take another look at what automation really is. There have been many definitions and a lot of disagreements on them. For the purpose of this article, however, automation is defined as any device which takes manual effort out of any process or operation. This definition includes all devices, whether they are motivated and controlled by punched cards, magnetic tapes, mechanical or electronic means or a combination of any of these media.

From the above definition, it is obvious that we have had automation with us for a long time, although it was not identified under that name until recently. It has been in the factory since the first production line was set up. The office has had it for years in the dictaphone and other office machines. The home and even the farm have known it though several labor saving devices. What then is the magic formula that has suddenly awakened American industry to the benefits of automation? What are the reasons for the accelerated push to more and more automatic operations? Let us point out a few of the major ones before we review the factors that must be given consideration in most future business decisions.

Pressure Toward Automation

The answers to the questions asked are so numerous and varied that it is impossible to list them all. There are, however, some major reasons for the swing to automation which should be examined. The benefits to be gained through such action also merit consideration.

First, increased wage rates have put a premium on the use of human labor. Union demands for higher and higher pay, whether in the form of fringe benefits, hourly rates or guaranteed annual wages are aggravating this situation. Management's only alternative is increased productivity, in units per man-hour. This is the only course that will allow industry to bear its ever increasing

burden. Automation has the complete answer; its benefits can be distributed to workers, management, consumers and stockholders.

Next, competition has returned with a vengeance. Managements of progressive companies are getting set for even more rigorous competition. They are introducing new or redesigned products produced under the latest low-cost manufacturing methods. They are out to get a greater share of the market. Loss of a considerable portion of our domestic, as well as export markets, to low cost labor in foreign countries adds several more straws to the camel's back. A good example is the bicycle industry which has already lost over half of its market to foreign competition. Many more industries face the same dilemma. The issue becomes crystal clear, there is only one solution—automation. It's either automate or risk bankruptcy.

Let's look deeper at this survival angle. There is no doubt that all of the Iron Curtain countries are redoubling their efforts to capture all or at least a major share of our export markets. Time alone will tell how serious this threat will be, but with low-cost slave labor and modern production methods, they will no doubt make some inroads into our markets. After all, even these countries are automating. In the end, however, the American enterprise system should come out on top. The inferior grade of their products, as well as the lack of incentive, should bring about their downfall.

Just as all past technological improvements, automation will materially increase our already high standard of living. Ease of living and elimination of drudgery and hard physical labor are the fruits of automation. More leisure time will be the result for the employee as well as the housewife. This leisure time could be in the form of a shorter workday or workweek, but more probably will be through extended paid vacation periods. The shorter workweek will come later, since the shortage of manpower to fill the necessary jobs will prevent its coming for several years. These benefits, even in the absence of any other compelling reasons, will add to the pressures to automate.

Coupling these with the other economic factors favoring automation, it is evident that we are beyond the point of no return. Automation is inevitable and is the formula for the future; it alone can furnish the ingredients of continued prosperity and further increases in our high living standards.

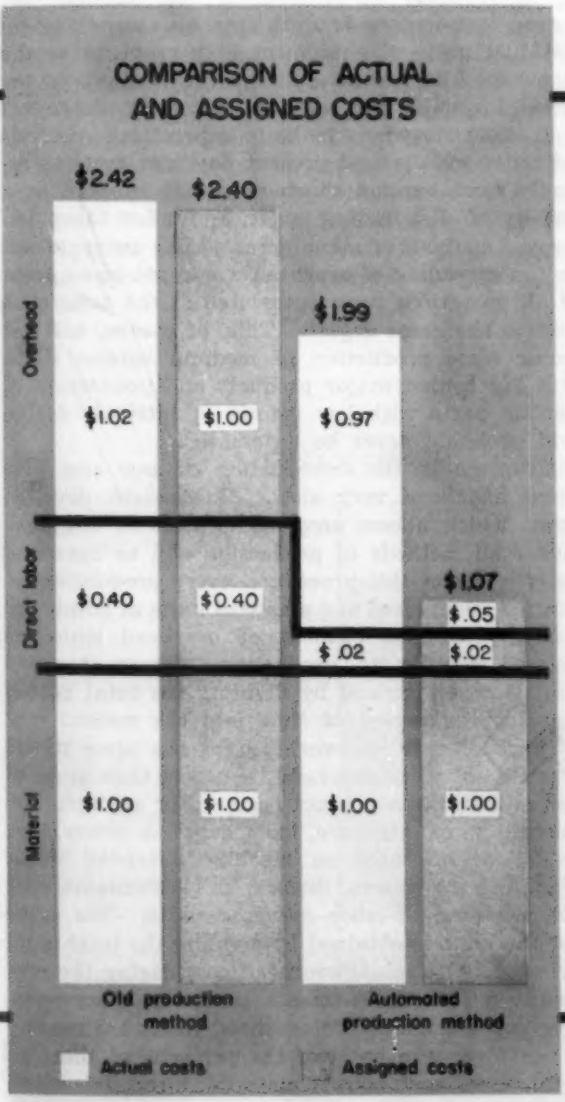


Fig. 1—Comparison of actual costs for old and new production methods with applied costs based on an old method of accounting (overhead distributed on direct labor basis) shows the need for new accounting methods. With overhead distributed on a direct labor basis between highly automatic operations and those which have not been automated, false cost figures are obtained for both types of operations.

▶ Accounting for Automated Operations

Studies of present accounting procedures will, in most cases, reveal that they do not lend themselves fully to automation. Changes and modifications must be developed and put into effect before they can be aligned to reflect the new developments in manufacturing methods. These changes must cover several points.

Distribution of overhead under present cost systems may no longer furnish accurate costing under automation. This is especially true of those where distribution of overhead is on a direct or prime labor basis. Under automation, the equipment will be very costly, with consequently increased costs for depreciation, maintenance, insurance and taxes, and with very little, if any, direct labor. It is obvious that direct labor cost cannot be used as a

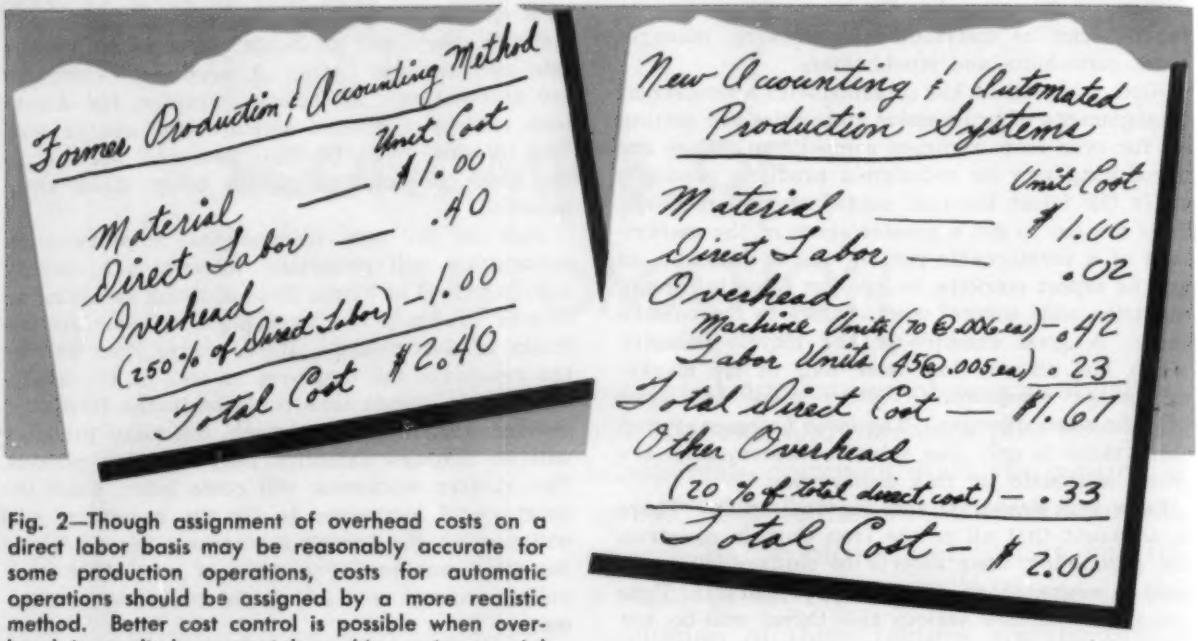

Former Production & Accounting Method
Unit Cost
Material — $1.00
Direct Labor — .40
Overhead
(250% of Direct Labor) — 1.00
Total Cost $2.40
New Accounting & Automated Production Systems
Unit Cost
Material — $1.00
Direct Labor — .02
Overhead
Machine Units (70 @ .006 ea) — .42
Labor Units (45 @ .005 ea) .23
Total Direct Cost — $1.67
Other Overhead
(20% of total direct cost) — .33
Total Cost — $2.00

Fig. 2—Though assignment of overhead costs on a direct labor basis may be reasonably accurate for some production operations, costs for automatic operations should be assigned by a more realistic method. Better cost control is possible when overhead is applied as special machine units, special labor units and a general distribution on the basis of total direct cost.

basis for distribution of overhead under these circumstances. This condition seems especially serious when we recognize the fact that a majority of the manufacturing plants use the direct labor cost for distribution of overhead.

A simple illustration of this point is the example in *Fig.* 1. Assume that prior to the use of the present automated method, part *X* was produced on machines requiring individual operators who produced an average of 5 pieces per hour at a piecework rate of 40 cents per piece. Production requirements were 1,000 pieces per day so the 10 available machines were operated full time on the first and second shifts and half-time on the third shift. Under automation this part is produced automatically on a single machine, in one shift, with a single operator, at a piecework rate of 2 cents per piece. The overhead actually created under each of these two methods was approximately the same. Depreciation is considerably higher with automation but is offset by elimination or reduction of expenditures for power, tools, shift premiums, fringe benefits, etc. In distributing costs, overhead was assigned on a direct labor cost basis by applying 250 per cent to direct labor.

Under this method of overhead distribution, automated operations do not absorb their pro-rata share of overhead and other operations are penalized. A similar cost situation would also result with the use of most other common bases now followed in applying overhead to products. This proves conclusively that it is imperative that new costing procedures be developed to give accurate overhead distribution under automation.

There is no simple solution to this problem or one solution that will cover all companies. In some cases, cost centers or work stations comprising individual units of equipment may prove to be the answer. The clerical detail, however, may be too great to justify this method, or variety of product and short runs may make it impractical. Analysis of other widely used present day cost systems reveals some serious shortcomings if adopted as a means of distributing overhead under these improved methods of manufacture. The discrepancies in the spreading of overhead would not be so great if all operations were automated at the same time and to the same degree. This, of course, will not occur since production of medium volume items will lag behind major products and production of certain parts with low volume or intricate design will probably never be automated.

Progress in the introduction of new cost systems has been very slow. One recent development which allows proper allocation of overhead under all methods of production will be described briefly. Under this procedure, every productive operation is analyzed and standard units or points are set up for each element of overhead which is related directly to production. These standard units are determined by dividing the total output for a given period of time into the normal cost of each element of overhead for the same period of time. Similar overhead items are then grouped for allocation as product costs. For example, depreciation, maintenance, tools, supplies, power, etc., would be allocated as machine overhead units. Handicap allowances, rework, shift premiums, etc., are allocated as labor overhead units. The value for the units is obtained by dividing the total units produced into actual overhead cost during the current year for the elements involved. Administrative expense and other overhead items are usually allocated on the basis of the per cent of these to total direct cost (direct material, direct labor and

machine and labor overhead). The comparison in *Fig.* 2 illustrates the calculated cost of part *X* under two different combinations of manufacturing methods and cost accounting.

The chief drawback to the unit cost system for allocating overhead is the time and effort required for research to establish the original standard unit for each element of overhead. These units, however, would remain constant except for changes in design or method of manufacture. This method allows application of overhead on a nearly direct charge basis, similar to the usual practice for direct material and labor.

Accountants must assist management in measuring the benefits under automation. This will call for astute judgment since historical data will present little help in evaluating the new manufacturing processes. The principle, however, remains the same—how much will costs be reduced and how much will profits be increased? The answer will be found in analyzing product unit costs under both the present and proposed methods of manufacture. This unit cost determination cannot be made in the usual manner but must be made on a specific or "out-of-pocket" cost basis. In other words, the unit cost must include only those elements which are affected by the method of manufacturing, eliminating those which are not affected by the production technique. The investment required would be an important item in the unit cost and should be pro-rated over a certain amount of production or a period of time. The quantity or period of time would be dependent on the size of the investment required, possible obsolescence of method or product, etc. But in most cases, it should not exceed a period of three years, *Fig.* 3. Return on investment may also be considered in some instances.

Another point of accounting difficulty under automation will be depreciation. Present plants, machinery and equipment will become obsolete at a much faster rate than has been the experience in the past. Present depreciation rates will no longer suffice and should be accelerated in those cases in which equipment will be replaced before it would be fully depreciated under present schedules. Although depreciation rates for tax purposes are largely controlled by federal regulations, recent changes in tax laws should be thoroughly examined and depreciation rates changed where possible and where required. The importance of watching market trends and technological advances cannot be overstressed. This will enable management to make claims for unusual obsolescence in the proper year. Inadequate planning prevented many industries from taking full advantage of recent changes in tax laws—poor foresight could be disastrous under automation.

This study of market trends and technological advances must include the possible elimination of entire operations or departments by automation. Improved equipment and methods of manufacture, along with new materials, changes in product demand or design, can alter the entire layout of a plant. Some plants have already experienced this in past technological advances. An example is afforded by operations which have eliminated wood shops because of changes in demand or through introduction of new materials. Such experiences could result in serious consequences unless such action has been fully considered and provided for. We can only predict more and more such occurrences in the future. At the present time, rumor has it that through the use of gamma rays plastics have been produced which are stronger than steel. This probably is exaggerated, but think of the seri-

MEASUREMENT OF INVESTMENT IN AUTOMATION

Savings per unit	Estimated annual sales (Units)	Investment required	Number of years to recover investment					
			0 1	2	3	4	5	6
$0.30	1,000,000	$500,000						
$0.40	1,000,000	$800,000						
$0.50	1,000,000	$1,400,000						
$0.60	1,000,000	$2,000,000						
$0.10	1,000,000	$400,000						
Feasibility yardstick			Safe		Borderline		Dangerous	

Fig. 3—Feasibility of proposed automation installations may be partially assessed by use of the rule-of-thumb type method illustrated here. Many supplementary measures and alternative methods are also available.

ous effect on a large segment of American industry if this were to become true.

Automation for Accounting

Automation of the office should also be considered. Over the past years we have made tremendous strides in accounting procedures and systems, budgets, and cost control, including plant management through accounting. The next step must, of course, be the reduction or elimination of the inefficiency of the army of clerical personnel that grew up like "Topsy" during this period of accounting development. At the same time, we must retain and improve our office procedures to provide assistance to management in attaining the utmost efficiency in plant operations.

This, we hope, will be possible with the introduction of improved data processing machines. Factual reporting programs for all levels of management must be reviewed in the light of possible changes in conditions. Current reports, including budgets, operating summaries and other business data will probably no longer reflect the inefficiencies and areas of costs which must be controlled. The solution is not in increasing the volume of reports or information but in furnishing more important and accurate data in simpler form. Management cannot digest all of the detail it now receives from present day office machines—what will be the result when the new electronic machines with their high speed printers take over. To justify their adoption, these machines should reduce the data to the bare essentials desired by management. Speed is a further consideration, and if most routine clerical operations are performed at night with machines, management will have available the following morning current operating data covering the previous day's operations.

Complete automation in the office is still dependent on several factors. Office procedures must be revised to fit and exploit available equipment. Some computations can be taken over in their present form but most will have to be redesigned to take advantage of the versatility of new equipment. Another factor that needs attention is the development of a modern common-language medium to integrate these modern machines. The widely-used five-channel punched tape may need to be replaced with something better. Office automation is also held up by the reluctance of American business to replace and write off present equipment in favor of automatic machines. It is realized that some of the electronic machines have not been fully perfected, proper programming has not been developed and trained personnel is not available, but a golden opportunity exists for the pioneer company to get the jump on its competition. The elimination of a load of office overhead will permit a company to undersell so burdened competitors to such an extent that it will enjoy a tremendous advantage. A final warning, however, is in order here. Although every office routine can be automated, some offices will discover that their volume doesn't warrant the special equipment and that a clerk will prove cheaper.

Design for Automatic Production

Effects of automation on product and machine design cannot be overlooked. It will surely be found that the design of many products is not ideally suited for automated production. Product engineers and machine designers must key their efforts to facilitate production under this new concept of manufacture. This involves recognizing an evolving situation including several particulars which will now be considered.

Basic designs or models must be developed to which special features, attachments or changes can be adapted to fulfill customer demands. Automatic equipment is exceedingly set in its ways. Without basic models, it would be impossible to secure the full benefits of increased production at reduced costs from these advanced manufacturing practices. Along with this development of basic designs, there must also be interchangeability of parts on various models. This is basic to fixed

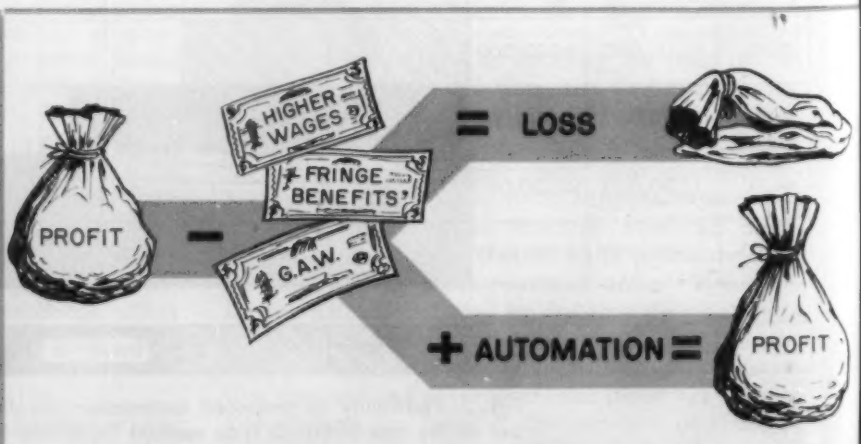


Fig. 4—Management actually does not have too much choice on the question, "Should we automate?" In many cases there is no good alternative. Automation may be the only way to avoid losses as wage rates and other labor costs increase.

automatic production methods. Short runs and variety must be the exception rather than the rule.

Product development must be keyed to the methods and tools of fabrication. It will prove impracticable to first design the product and then decide how to build it. The utmost simplicity must be designed into the product for lowest cost. This will add much to the ease of manufacture and will be a requisite in all future designing. The fact that a product designed for hand assembly is not designed for economical automatic assembly should be a major point in all design considerations. This new concept of design must be consistent however, with sound basic engineering principles and quality end products.

This change in design concept also places additional significance on forecasts. The demand for present and proposed products must be analyzed and co-ordinated with market research studies which forecast the long range outlook for product sales. The benefits of increased production at lower costs can increase market potentials and open entire new fields of demand. Competition for new designs and new materials will be much greater, increasing the danger of obsolescence of the product as well as production equipment. The increased capacities brought on by automation will also add fuel to the struggle for markets since the full potentialities of automation can only be achieved through capacity production. Proposed introduction and development of new or improved products must give full consideration to long range demands and trends. The perfectly designed product will prove of no avail if it does not have a ready market or will be replaced in a short period of time by a new material or custom.

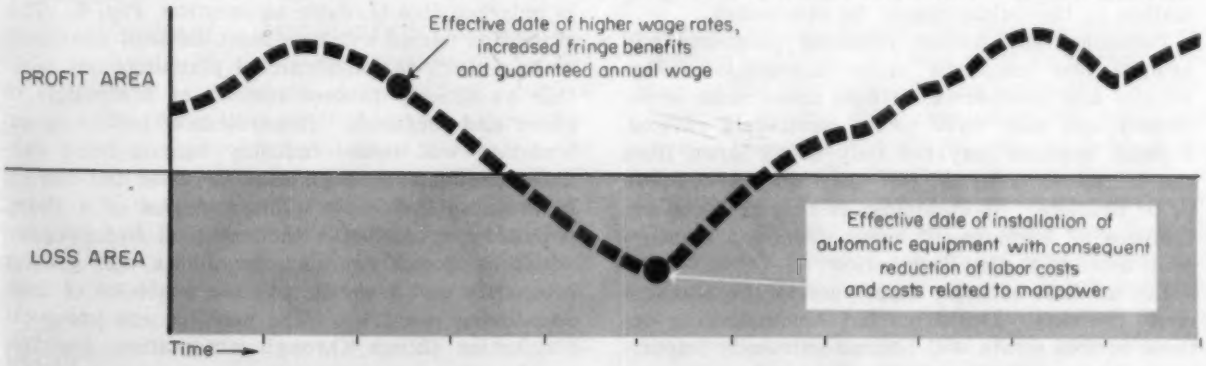
▶ Automated Manufacturing

Manufacturing divisions will face many difficult problems as a result of these technological advances. Solution of these problems may prove much harder than those faced by the accounting and engineering divisions. These problems will involve mechanical changes in equipment and tools as well as the changes necessary in the production, standards, planning, inspection and personnel departments. Proper investigation and planning will insure an orderly transition from present methods to the new and progressive industrial operations. Some of the more important items that should be considered will be discussed briefly.

Procurements of machine tools, equipment and tooling need to be carefully analyzed for possible use in automatic or semiautomatic manufacturing processes. Expenditures for all new facilities must be scrutinized to make certain that they can be utilized under future production practices. As pointed out previously, obsolescence will be extremely heavy on most of the present facilities, so it would be folly to aggravate this condition by adding equipment which may have only limited use under improved methods. Allied factors such as material handling equipment, storage facilities, operational sequence, etc., must also be resolved to meet these same requirements. The design of the new facilities is important too. They must have flexibility and capacity to produce all components which are basically similar. It may be possible to accomplish this by means of inserts or through mechanical ingenuity and thus reduce the investment required. Proof of this should assist management in selling conservative directors and stockholders on the benefits of expensive new facilities.

Maintenance in the automation era will become increasingly important. Most of this will, of necessity, have to be preventive maintenance, in order to eliminate or at least reduce to a minimum costly unexpected shutdowns. Automatic controls and signals must be developed and designed into the line to automatically warn of parts or tools which need replacement. Such controls must be designed so that expendable units can be replaced quickly and easily. Potential problem components must be replaceable instantly, one method being to plug them in like radio or television tubes. Plans and procedures should provide for preventive and corrective measures to be taken during lunch periods

EFFECT OF HIGHER COSTS AND INSTALLATION OF AUTOMATIC EQUIPMENT ON PROFIT AND LOSS CURVE


Effective date of higher wage rates, increased fringe benefits and guaranteed annual wage
PROFIT AREA
LOSS AREA
Effective date of installation of automatic equipment with consequent reduction of labor costs and costs related to manpower
Time

or between shifts. Actually, difficulties on automated lines will usually be less than on hand-operated equipment.

The reaction of employees and the public to automation is a psychological problem which must be considered. The threat of labor displacement will be vigorously discussed by both the workers and unions, in the belief that automation will mean job dislocation and unemployment. Many union leaders are prone to label automation as a curse rather than the blessing it really is. Unfortunately this view also is shared by a large part of the public. The objections of workers and union leaders can be dispelled by a full presentation of the benefits to be gained by them. Technological progress has never reduced total employment and it has created jobs. Without past improvements, there would be no mass production, and without this, there would be few of the benefits labor has received (for which the unions claim most of the credit).

Displaced employees will, in most cases, be absorbed in stepped-up production schedules and, with some training, into new and more highly skilled jobs. The physical burden on individual workers will be practically eliminated, making for reduced worker fatigue and greater safety. Some workers, of course, will have to shift to different industries but this is the usual pattern in some localities now because of seasonal demands. Then consider the multimillion dollar industries being created by automation—where are the workers for these new industries to be found? History shows us that labor shortages have always followed great technological advances. On top of this, increased demand due to lower prices will insure greater job security. This security will be accompanied by increased earnings since most jobs will be of higher skill types paying higher rates.

Overcoming objections of the public should not prove too difficult. The easiest way of winning consumers over will be through a reduction in selling prices which is possible because of lower production costs. It is realized that automation is costly and that companies need the initial savings to get back some of their investment, but lower prices should not be too long in coming. Competition will probably take care of this. Quality need not suffer to obtain lower prices, and can be increased under automation by elimination of human processing errors. The advisability of developing a public relations program to sell automation to the public cannot be overlooked.

Personnel and human relations programs will acquire new emphasis under automation. Our policies and procedures in these areas must be reviewed and may have to be completely revised. Present systems may not only break down from the increased demands but they may also prove to be obsolete. Shortcomings in this area can encompass all employment levels, from top management down to the lowliest worker.

Let us first consider employees in the management function. Decisions and accompanying actions in this strata will become extremely important in an automatic plant. Errors in judgment or wrong decisions will prove much more costly than under present operations. In some instances such mistakes could approach disaster levels and this possibility is furnishing ammunition to those who are demanding additional federal controls in industry. Sufficient technical backgrounds will be required at all levels. In most cases, comprehensive training programs should assist present management employees in developing the necessary skills and judgment to handle their new assignments. Those who do not develop the necessary abilities will have to be weeded out and replaced. In any event, extensive training programs, including brush-up courses at universities, job rotation plans and conferences-in-training, will become a *must* for management people.

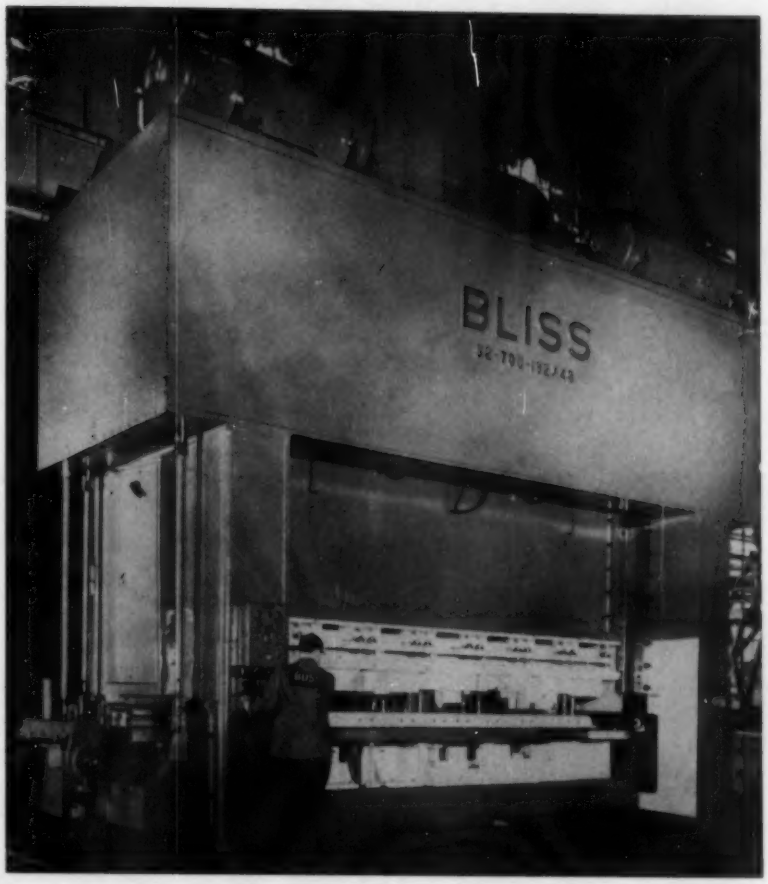
Now what about production workers? Present indications are that they will give way to teams of skilled technicians, controlling and maintaining individual automatic units. Proper training and instruction will provide a majority of the present workers with the necessary technological knowledge to fulfill the demands of their jobs under the new conditions. But what about those who aren't capable of being trained and upgraded? These employees, many of them probably loyal long-service workers, will have to be used in auxiliary jobs, pensioned or laid off due to their lack of skills or ability to attain them. This proposes a real problem. Plans should be made before the issue arises.

New yardsticks for measuring operating efficiency must be developed. Present procedures will no longer prove adequate. The much used ratio of productive to nonproductive employees will not suffice, since productive employees could be entirely eliminated in extreme cases and the number of nonproductive workers will probably increase. The new ratios and yardsticks may not be too difficult to design, but getting management to accept them is another problem. This too can be solved but the necessary educational program might as well be determined now.

While widespread automation may not be here tomorrow, it will be here soon. We are still in the pioneer days of automated production, but we are definitely out of the horse-and-buggy stage. The year by year increase in production costs, especially labor rates including fringe benefits, can be justified only on one condition—that each worker produce more each year. This higher productivity per man-hour (with less physical effort) is only possible through automation, *Fig.* 4. This transition period will be a most difficult one. Alert management, through careful planning, can make this an orderly process instead of a struggle of chaos and confusion. Regardless of problems, automation will come—industry cannot build outdated products by outmoded methods and remain in business tomorrow. The stimulus of a rising population combined with continued technological advances furnishes the ingredients for greater prosperity and a solution to the problems of freedom-loving countries. The benefits and prospects for better things through automation are tremendous.

1

Not only a press but a complete system for automatic production of refrigerator pans is the way the installation has been described. In addition to the press itself, E. W. Bliss Co. engineers designed, built and synchronized the operation of a coil cradle, straightener, roll feed, complete seven-station transfer feed system and tooling. Facts and figures about the 700-ton press: It is a straight side, single action, double geared twin drive press of four-piece tie rod construction; 192 inches between uprights and 48 inches front to back. It has an automatic lubrication system, and is wired to JIC standards. Equipped with General Electric combination press and motor controls, its 18-inch stroke has a motorized adjustment of 6 inches. The clutch is an air friction, crankshaft mounted type, and designed to permit replacement of linings without removal of clutch from shaft. Power source is a 100-hp General Electric main drive motor.



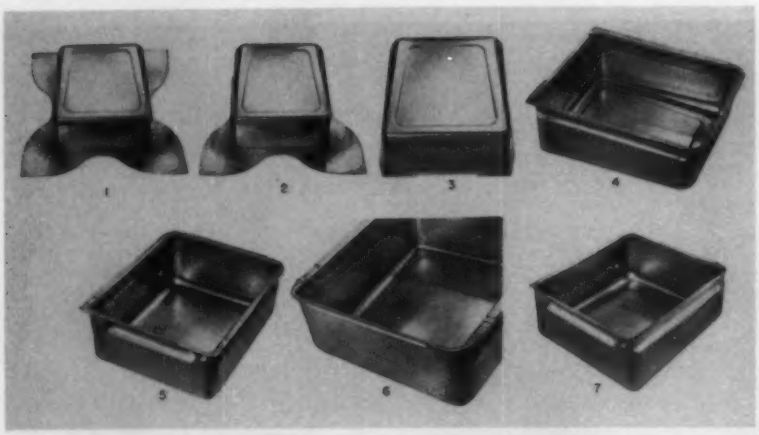
AUTOMATION TODAY

TRANSFER FEEDING STAMPINGS

AUTOMATED PRODUCTION facilities can capitalize on the latest developments in machinery. Although transfer-feed presses were built as far back as 1896, recent advances in their design have increased their utility for the manufacturer of complex stampings. Three E. W. Bliss Co. transfer-feed presses recently installed at Appliance Park, Louisville, Ky. produce all of the refrigerator pans and shelves General Electric needs for its annual output of more than a half million refrigerators.

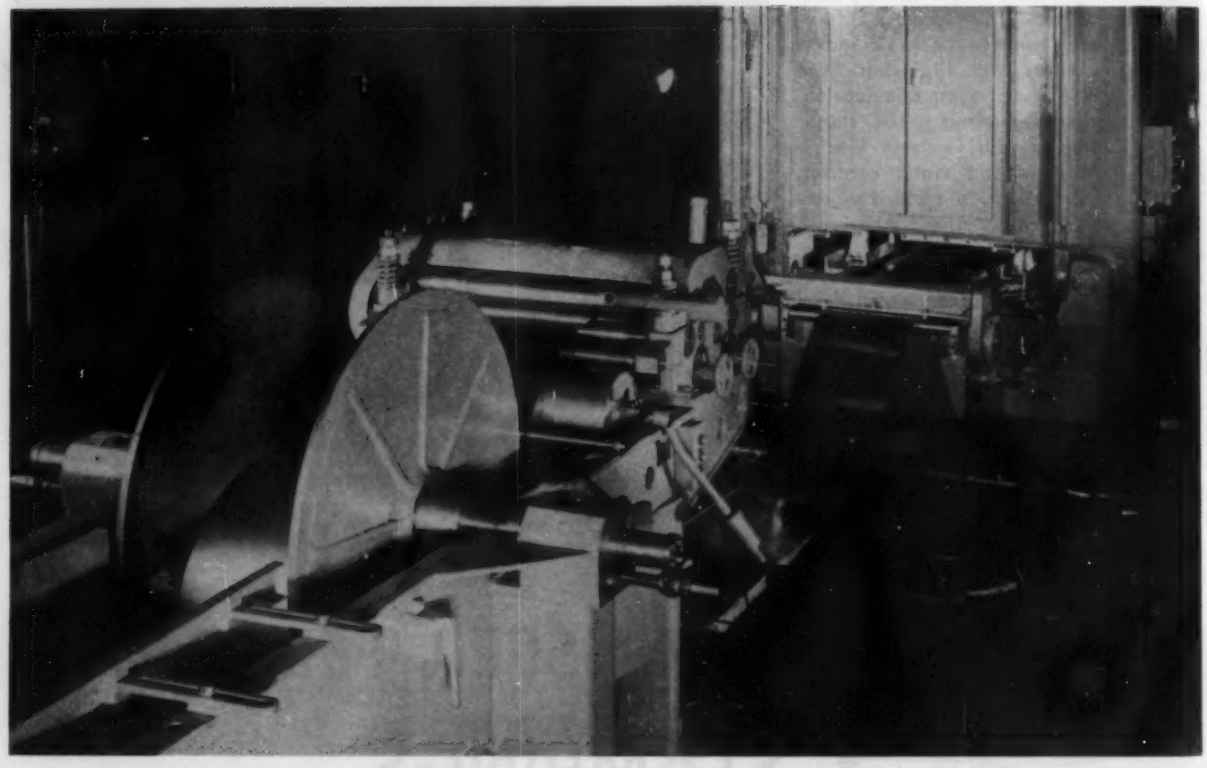
Production of these parts formerly required the services of two or three vendors, doubling or tripling the cost of dies and creating difficult expediting problems. Perhaps most significant, however, is the fact that with the automatic coil handling equipment Bliss has designed for these presses, General Electric is able to produce its stampings directly from regular mill coils.

There are three separate press lines involved. One is a 700-ton, seven-station Bliss transfer-feed press (with powered coil cradle, straightener and roll feed) that produces 12 deep-drawn refrigerator pans per minute and feeds them off onto a conveyor automatically. The other two—identical to one another—are 800-ton, transfer-feed presses



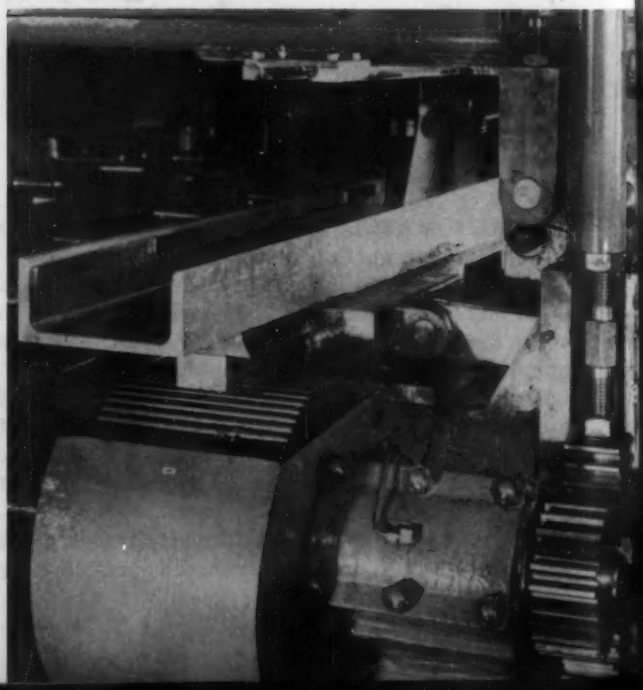
2

Sequence of operations in making refrigerator crisper pans: (1) Cut off 22 by 24-inch blank and deep draw to approximately 11 inches wide, 13 inches long, by 5½ inches deep, (2) rough trim rear half of flange, (3) rough trim front half of flange, (4) cam form sides of pan, (5) cam form front recess and pierce holes in sides, (6) curl rear flange and form indentations in the side flanges, (7) finish trim rear flanges. Scrap from these operations falls through the press bolster and onto a conveyor in the pit below.



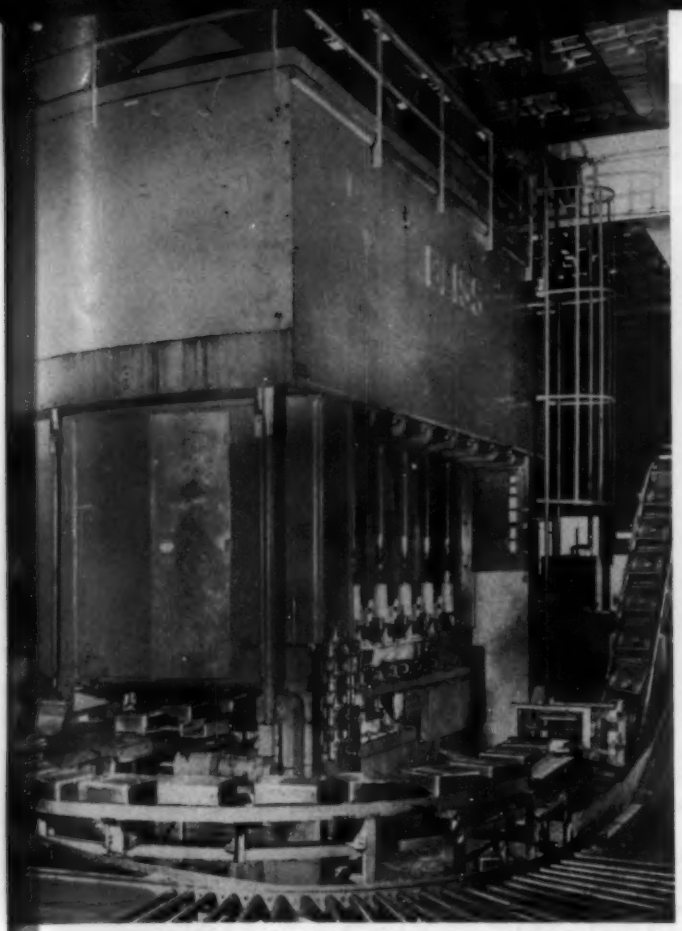
Close-up of coil cradle and straightener shows how stock feeds off the coil, through the five-roll straightener, into the roll feed (attached to press) and into the first position of the transfer feed. Ordinarily, a second roll is held in readiness at the rear of the coil cradle.

3



4

Transfer-feed mechanism is shown here with the cover removed. Two channel bars extend the full length of each press, and the feed fingers that move the parts from one die set to the next are bolted to these bars. Two pairs of driving mechanisms, one on each end of the press and linked by yokes to the main shaft, control the movement of the channels. One pair directs their lateral movement (left to right), and the other pair directs the in-and-out movement of the bars. Since the drive is taken from the ends of the main shaft, there is no danger of the feed drive getting out of time with the press slide.

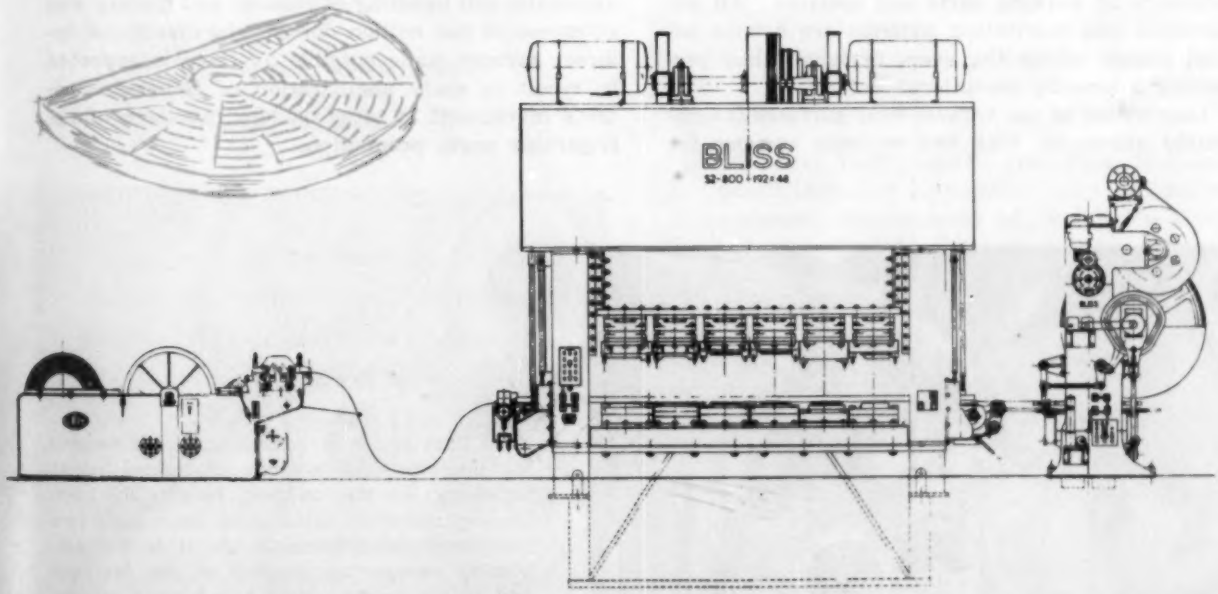


equipped with coil cradle, straightener and roll feed. Each of these presses produces rotary and stationary refrigerator shelves at the rate of 15 per minute directly from standard mill coils.

The method of operation is common to all three. Standard mill coils, up to 6000 pounds, 54 inches in diameter, and 22 inches in width are loaded onto the coil cradle. The coil winds off the cradle at the desired rate, goes through a motor-driven five-roll straightener and into the synchronized roll feed of the press. From there, the strip goes to the first station of the press where it is cut off. Transfer feed fingers, driven by cam and gear linkages from the main shaft, move in on the work-piece and carry it to the next station. As the press slide descends, the fingers move out; as it rises, they move in and repeat the cycle. The cycle is continuous, feeding new strip to the first station and delivering a completed part with each stroke of the press.

Each press has seven stations—although only six stations are used on the two 800-ton presses making shelves. The extra station was built in because future production of different models might require it. The presses reflect design flexibility in other ways: Each die station is equipped with a "sub-slide" which makes it easy to change and adjust dies, and the feed fingers can be replaced to suit special work handling problems. In

5 Refrigerator pans are completed at the rate of 12 a minute and leave the press on the conveyor line that takes them to the pickling and enameling operations.



6 General Electric's Louisville plant also has two lines like this, side by side, each operating through two shifts at 15 strokes per minute. Based on a 16-hour day, and 50-minute hour, the lines will turn out 24,000 shelves per day. Mill coils are loaded onto the coil cradle at left; strip feeds through straightener, into roll feed, and into transfer mechanism of press. After cut-off at first station parts move through five more stations, and then leave the transfer feed press and are fed into an 800-ton embossing press (right).

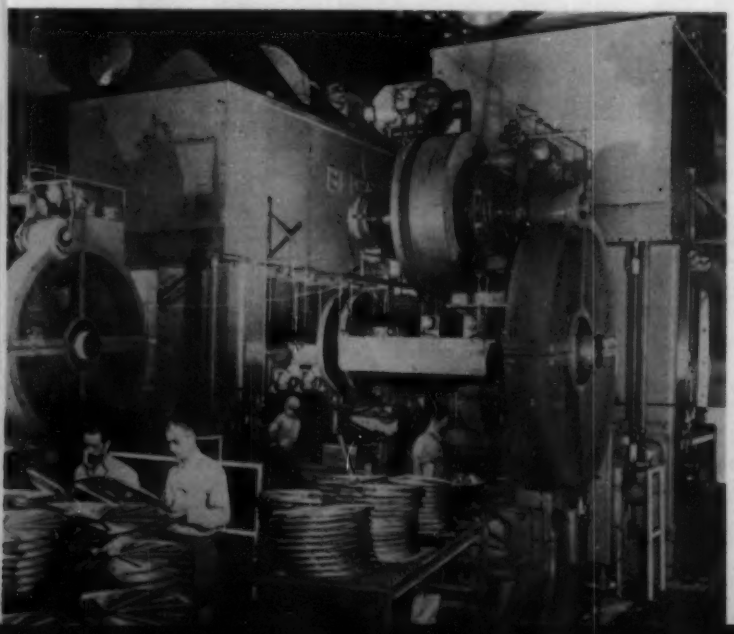
7 Once an attendant threads the end of the coil through the power-driven, five-roll straightener and into the roll feed, operation is completely automatic. The coil cradle will handle 6000-pound coils with a maximum diameter of 54 inches and a width of 12 to 36 inches. A second coil, held in a tilted load table, is lowered into feed position by air-operated cylinders, thus cutting handling time between coils. The sequence is: (1) Cut off and draw, (2) form sides down, (3) pierce half the total number of slots, (4) pierce the remaining slots, (5) trim all around, (6) extrude the slots.

addition, the coil cradles are adjustable for various sizes of strip, as are the straighteners.

The design of the presses themselves represents a trend within the industry—the complete enclosure of working parts and controls. All air, electrical and lubrication controls are housed behind panels within the press uprights, thus presenting a smooth, uncluttered exterior.

Lubrication of the various wear surfaces is completely automatic, with two separate systems for the transfer feed yokes alone. Electrical interlocks in the lube lines will shut down the press if lubrication is not at proper pressure.

While the total installed cost of the presses, automatic coil handling equipment and tooling was in excess of one million dollars, the direct and indirect savings made possible by them is expected to result in early amortization of General Electric's investment in these modern processes of refrigerator parts production.



8 Shelf lines end with embossing. If it weren't for the size and tonnage limitations made necessary by the building height, this embossing operation could have been built into the transfer-feed presses. As it is the embossing presses are located at the feed-out end of the transfer feed presses and require little extra space. The shelves leave the transfer-feed presses and are fed automatically to the embossing presses. Unloading, however, is achieved by hand, and the shelves are then loaded on conveyors for further processing.

An AUTOMATION MANAGEMENT CASE HISTORY

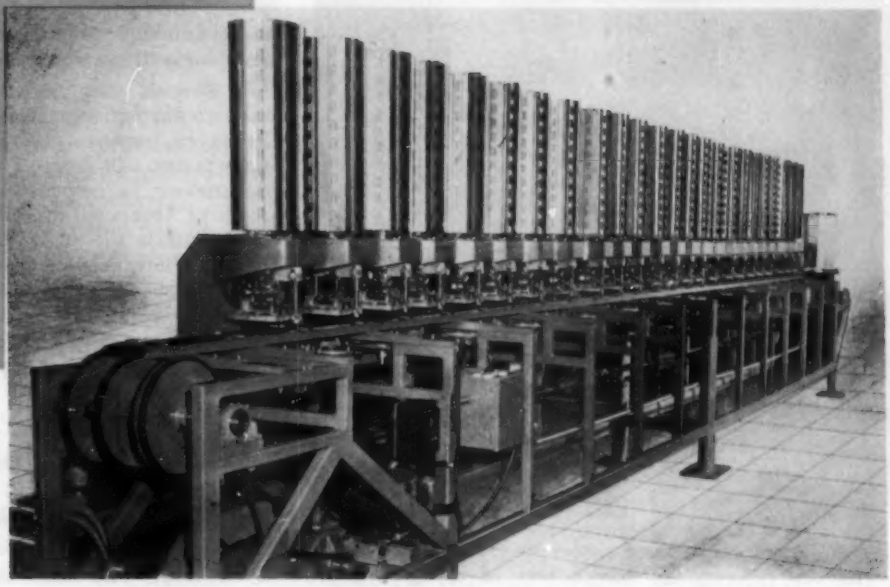


Fig. 1—Studies undertaken by IBM showed the importance of mechanizing the mounting of electronic components in printed circuit boards and led to the acquisition of this automatic assembly machine developed by General Mills Inc.

IBM TACKLES THE PROBLEM OF

JOB SHOP AUTOMATION

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Though their production requirements approximate job-shop conditions, IBM management has tailored an automation program to their specific needs. The results? In logical well organized steps, special manufacturing projects advance through the successive stages of study, research, pilot construction, and finally installation with the realization of the potential of automation.

DURING this postwar era when the new possibilities for automation have become so apparent, improvement of production facilities and procedures has been of major concern to the International Business Machines Corp.

It is well known that IBM's marketable products have been built primarily for the purpose of increasing efficiency in the fields of administration and scientific research and development. It has been our experience that the knowledge acquired in designing business and computing machinery and systems finds ready application within the plant. For example, data processing operations within the company offices cannot be divorced from the fabricating operations in the factory since manufacturing itself is a form of data processing. In manufacturing, concepts developed by the engineering staff together with market information analyzed by the management staff are translated into a specified number of objects of desired shape. The entire complex of research, design, production, sales and management rep-

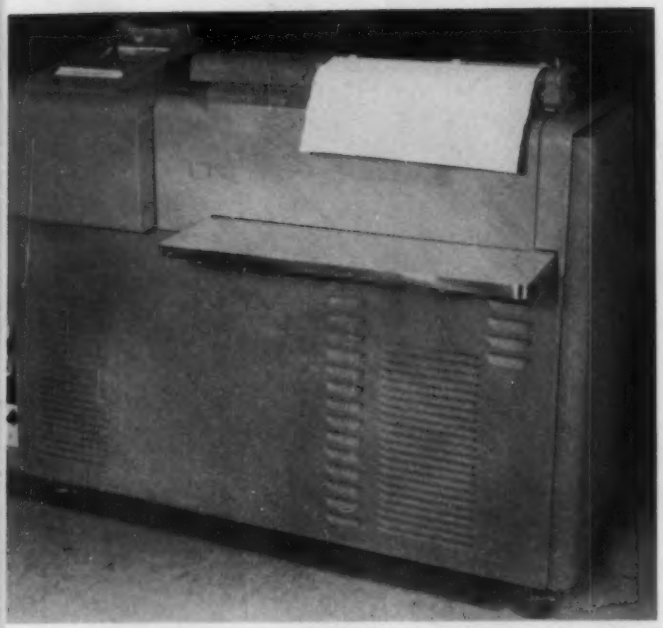

Fig. 2—Card-programmed automatic tester performs desired test on installed components of a machine to which it is connected. Results of test are automatically printed on paper or punched on cards.

resents an integrated whole, capable of general, systematic automation.

Approach To Automation

Many of the devices made within IBM are electronic; many others are electromechanical. Close tolerances must be followed. A large variety of intricate parts is required, but the majority of parts and assemblies manufactured are produced in medium or small numbers relative to those in such areas as the automotive industry. The overriding principle which is followed in automating IBM's factory operations is the development of systems and equipment which best fulfill the company's special requirements.

The responsibility for selecting, designing and building manufacturing equipment and establishing manufacturing procedure at IBM's Endicott plant lies with the manufacturing engineering division. Included within this division's sphere of activity are questions concerning factory automation. In attacking automation problems, the Endicott manufacturing engineering division has used the following procedure:

1. A careful and exhaustive study has been made of the various ideas relative to factory automation which have been advanced within recent years.

2. Conferences were held with leading proponents of various automation systems. Special groups within the company were established to investigate all possible approaches to factory automation.

3. Outside consultants were called upon to make studies of IBM's problems and to recommend solutions.

4. A mechanization and automation committee, consisting of senior members of the manufacturing engineering division, was formed within the Endicott plant. This committee was given the basic responsibility for determining which of the many ideas for more automatic operations would be used, and where and when they would be used.

5. Several new departments within the Endicott manufacturing engineering division have been established to perform various functions connected with automation. Of these, the manufacturing research department is responsible for research and development of advanced and unorthodox systems, equipment and methods for all types of factory processes where new or advanced technology is needed. The electronic test equipment engineering department is responsible for designing and building special equipment for testing electrical and electronic equipment. The special machine tools and machine engineering department designs and builds special machine tools and operates them on pilot runs.

The general requirements of IBM's production dictate the necessity for a highly flexible overall approach to automation. A large investment in special, built-in assembly lines would not pay their way. The need is for equipment and installations which can be made to change their output from one product to another rapidly, and with little set-up effort. Machinery for this purpose must be highly accurate, dependable, easy to maintain and free from low-order, close human control. In brief, what amounts to job-shop automation is required. Equipment filling the above requirements is, in general, not commercially available. The automation program involves designing and building, either alone or in co-operation with qualified vendors, equipment which will fit the requirements. Integration of the various machine operations into a system must follow development of the machines themselves.

Digital Feedback Control

The equipment required falls generally into three categories: fabricating, assembly, and testing. A study of the requirements for job-shop type automation indicated that the best approach to follow was that of digital, feedback automation under the control of programs stored on punched cards or tapes. The decision to concentrate primarily on digital feedback control was based on the following factors:

1. Use of feedback permits accuracy of results essentially independent of the quality of the physical drive linkage.

2. When feedback is not used in the manufacture of parts to the close tolerances required by many data processing machine components, machine tools must be built and maintained to such accuracy that tool costs are prohibitive.

3. Normally, tool and driving gear wear must be kept almost to zero. Feedback provides automatic correction for wear and backlash, thereby permitting great accuracy with machinery of ordinary mechanical precision.

4. Feedback also eliminates the necessity for many separate inspection steps by performing inspection operations concurrent with shaping and assembling.

Digital type feedback has several advantages in most IBM operations over analog type. In the first place, digital data handling is more flexible. Close design of a specific feedback loop is not required if the information is handled in digital form. Instructions and feedback information can be counted, compared, translated, amplified and summed with ease. Identical comparing, transmitting, counting and logical elements can be used without modification in various situations, controlling entirely different operations at varying power levels. As a second advantage, the accuracy of digital feedback control systems is limited only by the accuracy of the input data. Analog elements possess accuracy limitations inherent in the particular system. To achieve high accuracy with analog loops, very high-quality instruments are required.

A third advantage of digital feedback is that electronic data processing machines and other IBM equipment handle data in digital form. No conversion is required to connect digital automation controllers and other data processing equipment. This permits direct transmission of programs prepared in computers to automation controllers without translation. Finally, transmission of data in digital form is more easily achieved than transmission of analog voltages.

▸ Project Selection

The decision to undertake the automation of a particular operation is made by the regular line executives under recommendation of the mechanization and automation committee and the staffs of the departments most intimately concerned with production operations. In certain circumstances, the decision to undertake the manufacture of a product or an entire line of products depends upon the possibility of automatic production. In such cases, the cost of automation must be included in the product planning considerations.

Where a project for the automation of an existing process is under consideration, a number of factors must be weighed. These are: (1) The unit saving which can be achieved by automation; (2) the probable length of time which the part or assembly concerned will continue to be manufactured; (3) the cost of research and development involved; (4) the overall dollar gain expected; (5) the possible applications of principles and equipment developed through the particular automation research project to other manufacturing activities; and (6) the adaptability of the equipment developed to an overall automation system.

Proposed projects are weighed against each other on the basis of the above considerations, and the most promising, as budgetary consideration permits, are undertaken.

▸ Examples of Projects

A case illustrative of IBM procedures for automation is the manufacture of electronic assemblies. Applying the criteria outlined in the preceding section to this field, it became apparent that this would be a highly fruitful area for automation effort. All factors point to a rapid and continuing increase in the use of electronic components in IBM products. Some of these components are extremely difficult and expensive to manufacture by conventional methods. All are difficult to assemble. These considerations are so important that the actual company future can be expected to be significantly influenced by them. On this basis, a systematic approach to automation of the entire electrical manufacturing operation was indicated. Many details of this program are not yet available for publication but several items can be mentioned.

Two of the activities in which it was determined that automation was most urgently needed were the mounting of electronic components on printed circuit boards and the testing of installed electronic and electrical components of IBM machines.

As a partial solution to the automation of component insertion, the "Autofab" was developed for IBM by General Mills, *Fig.* 1. Further research and development is being carried on in this field (see AUTOMATION, April '55). For the testing of installed electronic and electrical components, the IBM manufacturing research department at Endicott developed a card-programmed automatic tester. This system is capable of performing a series

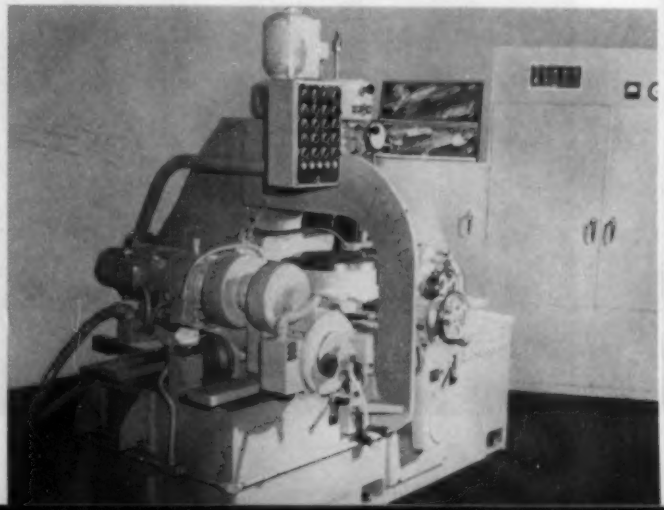

Fig. 3—To solve a problem, automation was resorted to by developing a tape-controlled miller which is used in production of precise master cams. Machine was built to an IBM design by Cincinnati Milling Machine Co.; controls were built in IBM's manufacturing research department.

of tests on the components of a machine to which it is connected and printing the results on a paper form or on punched cards, *Fig.* 2. To adapt the tester to use with a given machine, all that is necessary is preparation of a deck of program cards, which will direct the sequence and type of test performed, and construction of appropriate input cables from the tested machine to the tester.

In addition to the work toward automation of electrical manufacturing, research and development is being performed on other factory processes. For example, IBM machines use a large number of precision cams. The cams are manufactured by reproducing means using master cams as the model to be followed. Making these master cams was a difficult, laborious process. To simplify this process and produce more accurate master cams, a tape programmed cam-miller was designed and built. The machine proper was built to an IBM design by Cincinnati Milling Machine Co. The controls were built in the IBM manufacturing research department at Endicott, *Fig.* 3.

The Future

After sufficient programmable equipment has been developed and production tested, consideration will be given to higher order control of major operations. Automatic translation of design and sales data into signals controlling the factory equipment through the use of IBM electronic data processing machines is a logical step. Special procedures and translation devices must be designed for this, but the basic equipment requirements have already been met.

As to another important aspect of automation—the philosophical—our beliefs are built upon such factors as the dignity and stature of our employees, factors which have always been of paramount interest to the company. And since we feel that every technological improvement that reduces the monotony and drudgery of work and releases people for creative, interesting work is a positive gain for humanity—IBM has welcomed the recent expansion of interest in automation.

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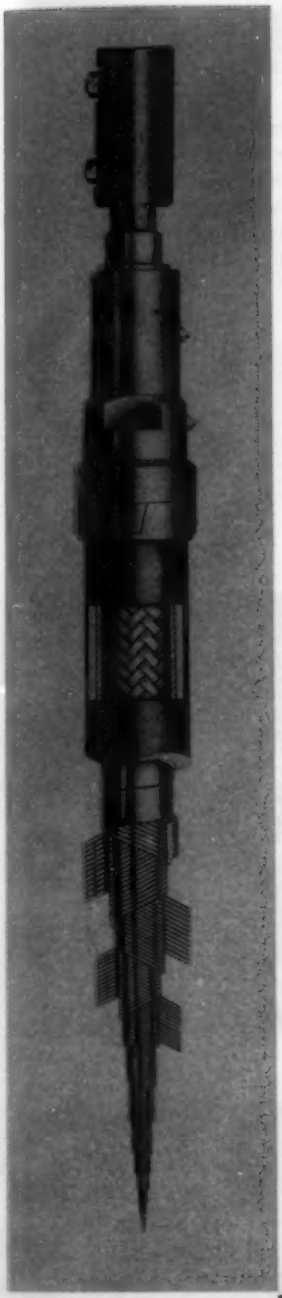
Box Closing System

PACKAGING of large items in corrugated boxes is considerably simplified with new equipment developed by the Hinde & Dauch Paper Co., Sandusky, O. Compared to methods now in general use, the system allows savings up to 30 per cent in packing labor. The equipment requires less floor space and permits a much faster packing operation.

System eliminates the work of putting a large, heavy object inside the box as the special bottom flap closing device permits the box to be introduced over the item to be packaged. With the item and box in place, two of the bottom flaps of a regular slotted carton are closed up under the item by swinging sections of a roller conveyor. Two flat plates which support the item while the flaps are being closed, are then retracted.

At a second station, interior packing is added to the boxed unit. The unit, with two top and bottom flaps turned out, then passes through a roller gluing operation.

Final sealing of outer flaps occurs as the box, which is supported by guide rails, is moved by two parallel powered belt conveyors through two separate flap closing operations. The illustration shows the spaced position of the parallel conveyors which permits first one bottom flap, then the second bottom flap, to be sealed by mechanisms actuated by limit switches.



TORQUE TRANSMISSION WITH FLEXIBLE SHAFTS

FOR HANDLING AND PRODUCTION

Complicated mechanical linkages are neither the only nor best solution to all tricky design problems involving transmission of rotary power or motion. An important possible solution is discussed in this article — flexible shafts.

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THE PECULIAR attributes of flexible shafting make it an ideal solution to certain types of problems involving the mechanical transmission of rotary power or motion—problems encountered on an increasing scale with increasing mechanization. As a general statement, the problems can be said to involve transmission of power or motion over a complicated path—complicated in the sense that there is relative motion between the components of machinery, or be-

Fig. 1—Standard flexible shaft has built-in ball or sleeve bearings and couplings on each end. This cutaway view shows how layers of wire are built into a flexible core and then covered with casing.

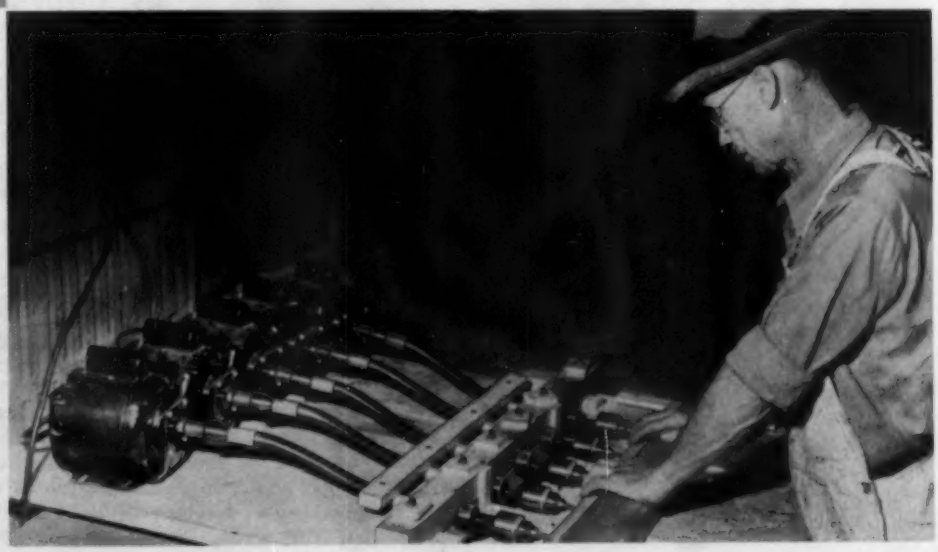

Fig. 2—Flexibility in a woodworking drilling installation is achieved with flexible shafts and is suggestive of advantages in having greater freedom in locating either the drive or driven component of a piece of equipment.

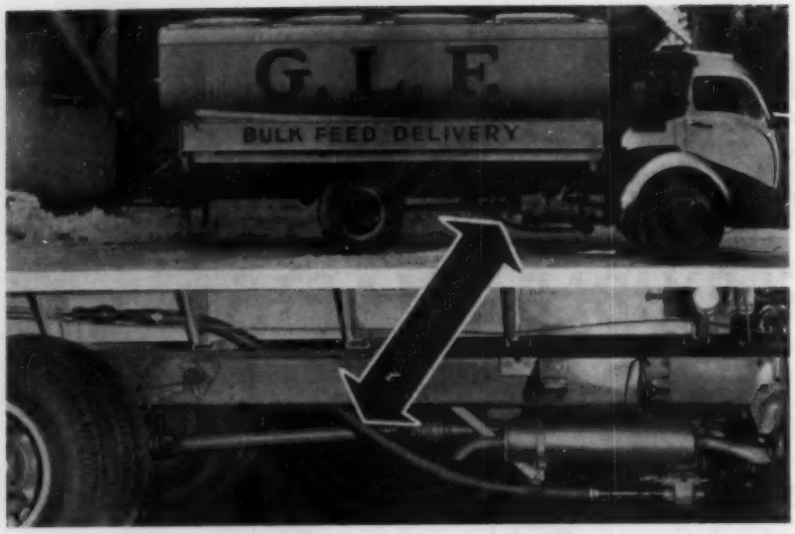

Fig. 3—Power take-off shaft drives an auger type conveyor through a flexible shaft. Three universal joints and two bearing blocks would have to be used to accomplish the same task with typical mechanical linkage.

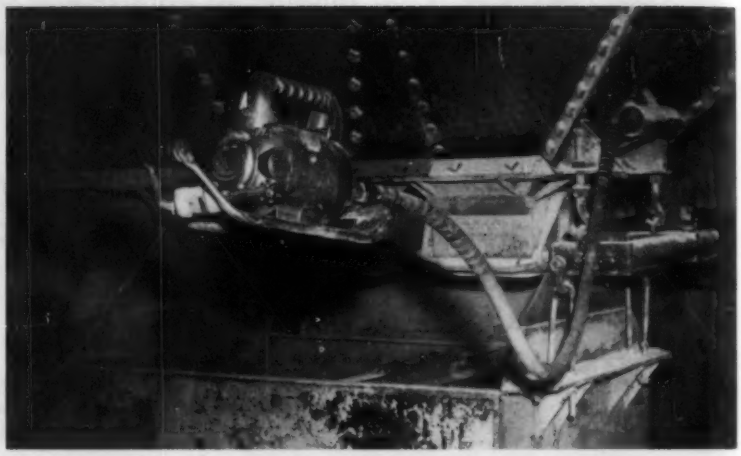

Fig. 4—Typical of applications ideally suited to a flexible drive are those involving vibration. Portable vibrator in illustration is used to speed the flow of cement in a bin.

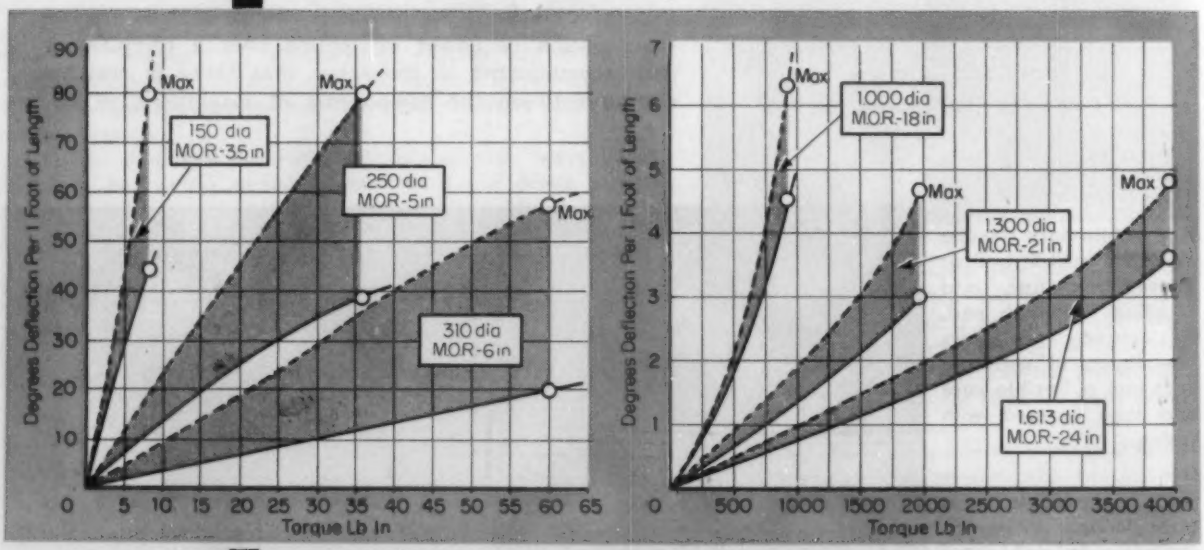

Fig. 5—Graphs indicate the deflection-torque characteristics of six sizes of remote control shafts manufactured by the Stow Mfg. Co. and are used in core selection. The factors to be considered when selecting the proper core are: (1) The torque, (2) total allowable deflection, and (3) the radius of curvature of the smallest bend in the shaft. Solid lines on the graph represent motion in the direction of wind-up; dotted lines represent motion in the direction of unwind. In choosing a core, the maximum static torque ratings must not be exceeded.

Rated speed RPM	MAXIMUM DYNAMIC TORQUE CAPACITY (LB IN) Straight and curved shafts Radius of curvature in inches											Wgt / C. Ft	Core Diameter	Core No. and Type
	50 to strgt	25	20	15	12	10	8	6	5	4	3			
4500	2.4	2.2	2.0	2.0	1.92	1.9	1.7	1.5	1.25	1.00	.50	3.0	.124 / .128	1 MH
3800	7.0	6.4	6.0	5.8	5.4	5.0	4.6	3.6	2.0	1.5		4.5	.148 / .152	2 MH
2900	9.4	8.6	8.0	7.6	7.0	6.6	6.0	4.8	3.4	2.0		7.0	.185 / .189	3 MH
2500	22.0	20.0	18.8	17.6	16.0	15.0	12.6	10.8	9.0			12.5	.247 / .252	4 MH
1800	30.0	28.0	26.4	25.0	23.0	21.0	18.0	14.0				20.0	.308 / .313	5 MH
1800	33.8	31.5	29.7	28.1	25.9	23.6	20.2	15.8				20.0	.308 / .313	6 T
1800	36.0	33.0	31.6	30.0	28.0	26.0	22.0	18.0	11.0			21.0	.324 / .329	7 A
1500	80.0	66.0	63.0	58.0	51.0	46.0	37.0	22.0				28.5	.368 / .374	8 A
1500	60.0	54.0	50.0	46.0	42.0	38.0	30.0	24.0				29.0	.387 / .393	9 MH
1500	90.0	81.0	75.0	69.0	63.0	57.0	45.0	36.0				29.0	.387 / .393	10 T
1150	136.0	110.0	104.0	94.0	80.0	72.0	56.0					50.5	.497 / .503	11 A
1150	148	124	110	92	72	56						53.5	.505 / .511	12 T
900	248	200	176	124	84							78.5	.610 / .618	13 T
900	220	204	192	180	152	130						80.5	.630 / .638	14 A
750	340	224	156	76								117	.747 / .753	15 T
600	760	520	420									205	.998 / 1.004	16 T
440	1500	720										343	1.298 / 1.304	17 T

Fig. 6—This chart is used in selecting the proper power drive shaft for a given application. The factors to be considered are: (1) The torque to be transmitted, (2) the operating speed, (3) the bends in the shaft, (4) direction of rotation, and (5) operating conditions. To prevent permanent distortion of the core, it is necessary to consider the maximum torque that the shaft will have to transmit. In this table, taken from data supplied by the Stow Mfg. Co., the variation for shafts at the same rated speed is due to the difference in core construction. The torque ratings given are for shafts that are adequately supported along their lengths; for unsupported shafts the calculated torque should be increased by 60 per cent. For a given shaft at lower speeds than indicated by the chart, the torque capacity does not increase; however, at higher speeds the torque capacity decreases as the speed increases.

cause of the relative location of the components which must be connected.

A flexible shaft consists of layers of wire woven into a core which is covered by a metal or rubber casing designed not only to protect and support the core, but also to provide a bearing surface for the core as it turns, *Fig.* 1. Because of different requirements, flexible shaft applications can be divided into two major types—one involves power drives and the other remote controls. The latter case involves rotation at such slow speeds that only the transmission of torque is considered.

Normally, power drive shafting has considerable directional qualities because of the method of manufacture. Rotation in the proper direction tends to tighten (wind-up) the outside layers of wire down on the center layers of the core. However, when operated in the unwind direction, the shaft will transmit only 50 to 80 per cent of its normal rating.

Remote control shafts differ from the power drives in the method of manufacture which, for the control type, results in almost equal two-directional torque properties. For instance, the deflection per foot of length for a ½-inch diameter power drive shaft when subjected to a torque of 80 inch-lb is 18 degrees in the direction of wind-up and 81 degrees in the direction of unwind; the deflection of the same size remote control shaft under the same circumstance is only 3 degrees in the direction of wind-up and 5 degrees in the direction of unwind.

The following illustrations, *Figs.* 2 to 4, indicate the range of application of flexible shafts, and though concerned with power drive applications, are suggestive of what can be done in the remote control field. Among the important features illustrated are: (1) Freedom allowed in locating components, (2) the connection of shafts having relative motion, (3) elimination of exposed rotating parts, (4) connections not affected by vibration, and (5) simplicity of alignment of parts. Shaft selection data is given in *Figs.* 5 and 6.

In many cases, if flexible shafting were not used, a prohibitively expensive arrangement of universal joints, bearing blocks, etc. would be necessary to accomplish the same job. In short, flexible shafts provide a simple and efficient means of transmitting rotary power and motion, and are equally simple to install and maintain.

PLANNING A LOAD CELL WEIGHING SYSTEM

IN THE MAJORITY of tank, hopper and bin weighing installations, general considerations arise which can be applied in preliminary planning of load cell weighing systems. These systems provide remote indication and control of weight in hazardous processes, flexibility in location of instrumentation, and are used as inventory aids, as controlling and indicating devices for both batch and flow processes and as safety devices in maintaining liquid levels. Minneapolis-Honeywell engineers have assembled these planning considerations for the potential user of such systems.

As with other weighing systems, arrangements utilizing Baldwin-Lima-Hamilton SR-4 load cells and a Minneapolis-Honeywell, Brown ElectroniK potentiometer can give only an indication of total weight of a system. This includes both the tare, or dead weight, and the actual weight of the substance within the container. In order to obtain accurate readings, the tare weight must be kept constant during the weighing cycle. Not only the tank weight, but the weights of material remaining in the tank after emptying, conveyors, piping, rain or snow accumulations, lagging, heating and cooling coils, and fluids contained in them all contribute to the tare weight. During design of a tank weighing system, each of these factors should be considered and the effect of its variation on the accuracy of measurement evaluated.

Extraneous loads on the system caused by wind forces, piping connections, side braces, and guy wires can all affect the accuracy of measurement if they change during a weighing cycle. Through proper design, these forces can be kept small and reproducible, and their effects can be negated by calibration of the instrument at the time of installation.

For high-accuracy weighing systems, piping to the tank should be provided with flexible connections or long, unrestrained horizontal runs. This minimizes the tendency of the vertical support provided by the piping to change as the system deflects under load, or grows with temperature.

If heavy valves or fittings are required in the piping near the tank, they should be supported with spring type pipe supports, which provide the greatest vertical flexibility. Side braces should be few, long, and horizontal; all vertical or angle braces should be eliminated.

Thermal lagging used on the tank should be sealed as well as possible since some types absorb large quantities of moisture, and could cause the tare weight to vary with humidity. For short-term weighing this is unimportant since it is a very slow variation, but this factor may be important on inventory systems.

With schemes where only half of the tank is weighed, accuracy can be maintained only so long as the fraction of weight carried by the weighing system remains constant. The fact that SR-4 cells are relatively stiff—deflecting only 0.005 to 0.008-inch under capacity load—makes such a system practicable.

Both temperature level and variation must be considered in weighing installations. Although load cells are compensated to maintain their accuracy and stability over a given temperature range, this compensation is most effective when all parts of the cell are at the same temperature. For installations where the temperature in the vicinity of the cells varies widely and rapidly, or where the cell is exposed to radiant heat, the load cell should be insulated. Changes in dimensions of the tank or bin and its supports due to temperature variations must be also considered.

Special precautions must be taken where load cells are subjected to corrosive liquids or gases. Cables should be laid in conduit which is carefully sealed or possibly pressurized to prevent the entrance of corrosive agents. An air purge may be necessary to protect the instruments from corrosive atmospheres.

When mixing operations are being performed in the tank, when heavy machines are being operated in close proximity, or when material is being dropped into a bin from a height, vibrations may be induced. These vibrations can adversely affect the weighing operation. If vibration is anticipated, the estimated frequency and amplitude of load fluctuation should be noted, so that the proper choice of instrument and cell capacity can be made.

Brown ElectroniK potentiometers can be recording and indicating or indicating only, with air or electric control action. Each instrument is finished to order after specific needs have been determined. Instruments can be supplied with special features which extend their usefulness in particular applications. Selector switches can be provided so that the instrument measuring circuit can be connected to any one of a group of weighing installations. Either manual or automatic switching is possible.

Many special weighing arrangements are possible with SR-4 load cells, some of which are: Automatically maintaining a certain weight in the tank, automatically discharging certain quantities from the tank, and regulating rate of flow. An arrangement is now in use to automatically feed definite amounts of liquid resins to processing kettles. Once the panel-mounted controls are set, the system will pump the required weight of the chosen liquid into the selected kettle, make a record of the weight delivered, purge the connecting pipes with steam, and await the next weighing operation.

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CAN COMPUTERS CUT YOUR COSTS?

Perhaps your company uses an automatic computer or should consider doing so. Many companies can profitably use computer systems. Considerations in determining profitability of such systems for specific data processing tasks are covered in this discussion.

CAN YOU SHOW that your company should use an automatic computer? To show that a company should use a computer requires weighing all the benefits to be received against all the costs to be incurred in using an automatic computer. Essentially, there are two types of these benefits and costs to be considered, those which are indefinite and those for which dollar and cents figures can be determined.

For a few companies, the indefinite benefits and costs are the controlling factors in management's decision on whether or not to acquire and use a computer. Keeping ahead of the competition, improving customer service, providing more accurate, more useful, and more timely information to the executives are some of the indefinite benefits that are often given most weight. Among the indefinite costs, the more common are the possibility of employee misunderstanding of the contribution of a computer, and the uncertainty and waste motion that sometimes occur when the installing of an automatic computer is not properly managed. They are properly matters for executive judgment.

Dollar-and-Cents Analysis

For most companies, the balance between the dollar-and-cents benefits and costs is the controlling factor in management's decision on whether or not to acquire and use an automatic computer. Determining this balance is something that middle man-

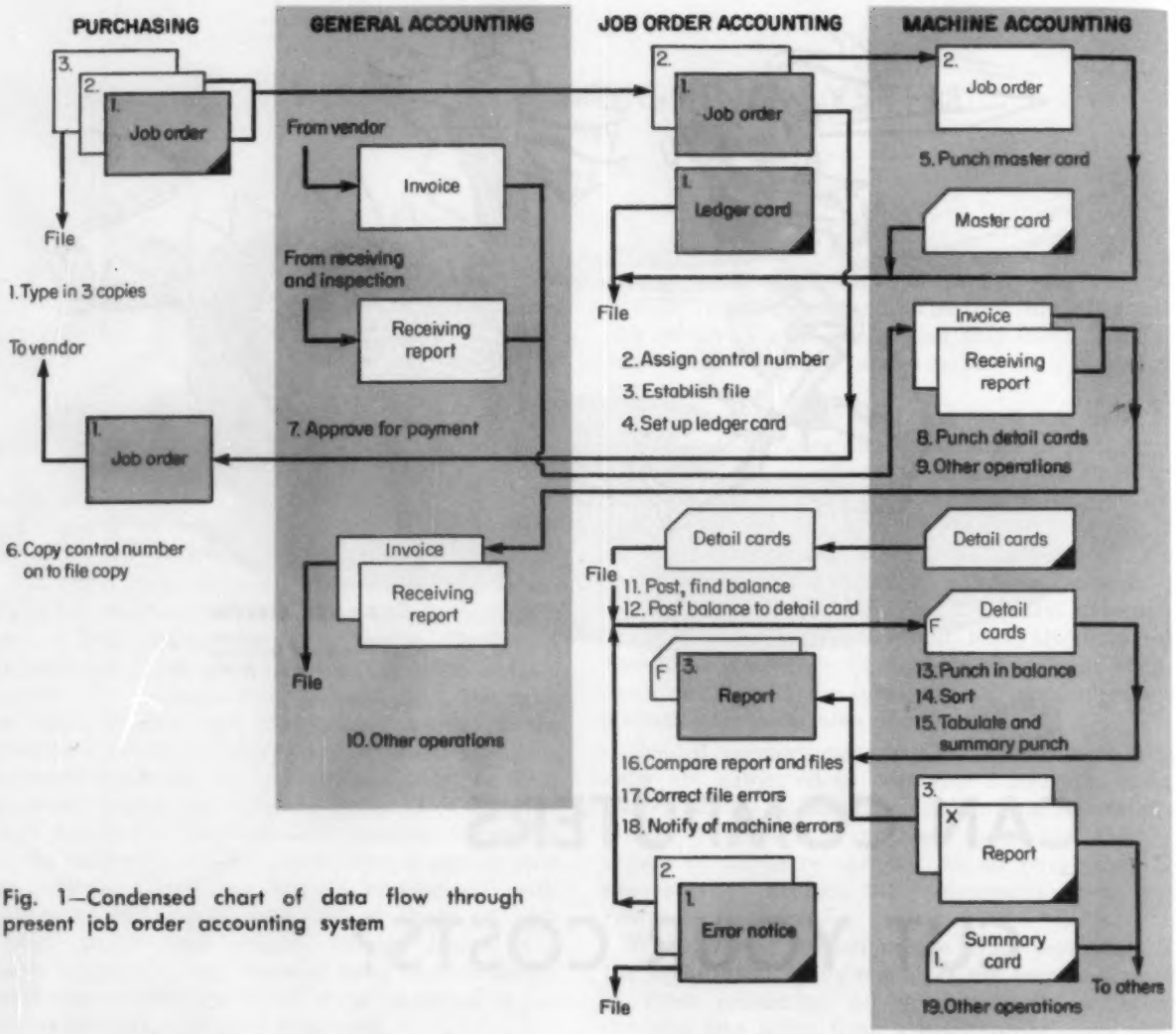

Fig. 1—Condensed chart of data flow through present job order accounting system

agement and staff personnel can do, and report on to the executives. The problem is how to do it.

To show in money terms that the acquisition and use of a computer is profitable requires a careful consideration of all the dollar-and-cents benefits and costs. These benefits and costs have three important characteristics. *First*: They can be controlled by management action. For example, the number of men on the line, the number of trucks being operated, the number of reports being prepared and circulated, are things which management can set at any desired level. *Second*: These benefits and costs can be measured. In business, what can be controlled can also be measured (although usually not as well as management would like) for measurement is the first step in control. *Third*: The benefits nearly always take the form of cost savings. This means that a comparative form of analysis is usable because a cost saving is always a difference between two sets of costs, and a cost increase is always a difference between two sets of costs. A comparative analysis puts into sharp focus the differences between the alternatives of using or not using an automatic computer. The advantages which one alternative has over the other must lie in their differences, not in their similarities.

Since the comparative form of analysis can be used, the problem reduces to one of tabulating the costs under present noncomputer systems, and then tabulating the cost increases and cost savings expected through the use of an automatic computer. To do this requires defining the specific applications which are to be put on the automatic computer and tracing through the cost changes that will result, for it is only the changes from the present noncomputer systems that are of significance.

This procedure assumes that some tentative automatic computer applications have been picked out, and that a systems analysis has been made to determine how these proposed applications could be done using a computer. For example, *Figs.* 1 and 2 show flow charts covering in condensed form a present method and a proposed system.

In tabulating the costs, the first step is to determine the cost of the present noncomputer systems for the proposed applications for a given period of time, such as a month. Usually the data available from cost accounting and from general accounting is not sufficiently detailed, so that it

becomes necessary to gather data directly. A useful technique is to first identify all the company's forms involved presently in the proposed applications, and then trace their usage through the company taking note of all employes and supervisors involved, and all supplies and equipment involved. Written procedures, flow charts, and job descriptions if available are very helpful in this work but they are no substitute for personal on-the-spot investigation.

To be most usable, the findings of the data-gathering investigation should be tabulated to show good detail within the three general categories of labor, supplies, and equipment. Labor should include all personnel engaged in the present system, whether engaged directly or indirectly. Under supplies include all the supplies and expendable materials used in the present system. Equipment rentals should cover amounts paid for the lease or rental of machines and devices used in the present system. Loss of equipment capital value should include the decline in market value of all owned machines and devices used in the present system. Also include interest on the beginning capital value. Indirect items (for example, maintenance work on accounting machines) should not be omitted, but normally no charge should be made for burden or overhead. However, if it is clear that the use of an automatic computer will change the company's expenditure for items of burden or overhead, then the full amount of the change, whether a cost increase or a cost saving, should be included in the cost tabulation.

In tabulating the costs, an important distinction must be kept in mind—the distinction between amortization costs and operating costs. The amortization costs are the accountant's estimates of the rate of recovery of money invested in assets, such as accounting machines, or a building. Amortization tends to keep cash in the business. Operating costs, on the other hand, are amounts paid in cash for things, such as paper, or for services, such as clerical help. Operating costs take cash out of the business. Because of their very different natures, amortization costs and operating costs must be kept separate.

In practice, the accountant's amortization costs serve as estimates of the change in value of the asset to the company (equal to the amount to be recovered)—this being the basic reason why declining balance or sum-of-the-digits amortization methods are better than the straight-line method.

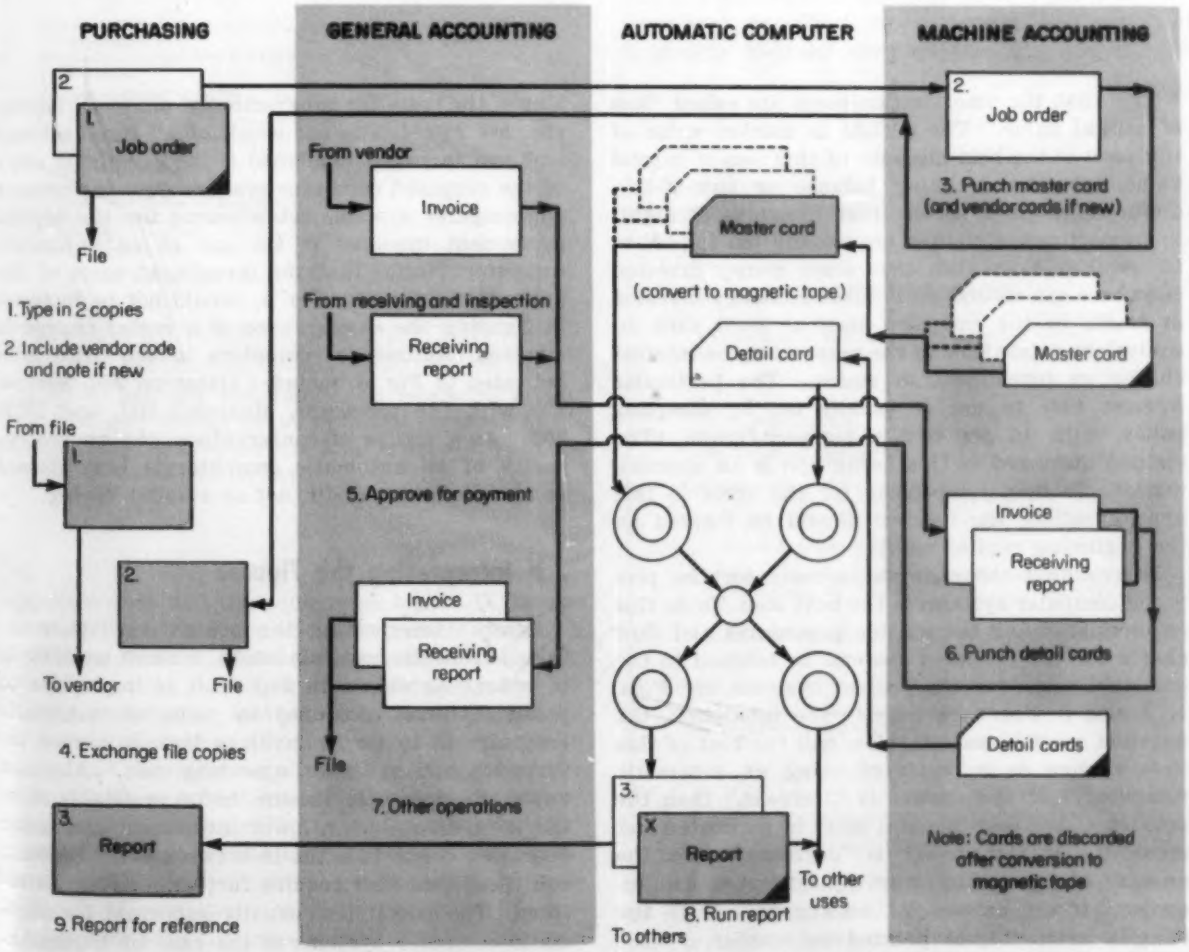

Fig. 2—Flow chart of proposed automatic computer system for job order accounting

AXC CORPORATION MONTHLY ESTIMATES

Automatic Computer Application Number 3—Job Order Accounting

Item of Cost	Present System Cost	Computer System Increase	Computer System Decrease	Comment
LABOR				
Purchasing Dept.				
Clerk-Typist	$710	$135		increase to 3 clerks
Job Order Dept.				
Supervisor	425		$425	
Posting Clerk	855		855	
Investigation Clerk	295		295	
Clerk-Typist	295		295	
Machine Accounting Dept.				
Key Punch Operator	275		410	gain from consolidation
Machine Accountant	70		70	
Receiving & Inspection				
Clerk	2560			no change
Inspector	9000			no change
General Accounting				
Assistant Auditor	200			no change
Payables Clerk	585			no change
Fringe Benefits		25	435	
Total		160	2785	
SUPPLIES				
Job Order Forms	390	15		prenumber drop one copy
Ledger Cards	100		100	
File Folders	90		90	
Punch Cards	25		25	
Receiving Report	1500			no change
Report Form	15			no change
Error Notice Form	5		5	
Other				
Office Supplies	200		15	
Total		15	235	
EQUIPMENT				
Rentals				
Key Punch	60		60	
Tabulator	50		50	
Sorter	10		10	
Collator				not used
Loss of Capital Value				
Typewriter	4		1	
File	5		5	
Desk & Chair	21		5	
Other Equipment	2		2	
10% Interest on Investment	12		2	
Total		....	135	
GRAND TOTAL				
Application No. 3		175	3155	

Fig. 3—Tabulation of present costs and estimated increases and decreases in costs under a proposed computer application

Notice that the amortization costs are called "loss of capital value." The decline in market value of the asset is the best measure of this loss of capital value, and the declining balance or sum-of-the-digits figure is a second best measure. Straight-line amortization figures are usually too far off to be useable. Note also, that since money invested elsewhere can always earn interest, money invested in assets in the company must at least earn an equivalent rate. This is the reason for the interest charge on investment in assets. The particular interest rate to use is usually set by company policy, with 10 per cent a popular figure. (The method discussed in this paragraph is an approximation. To help compensate for the error in this approximation, the interest should be figured on the beginning capital value).

Determining the changes in costs for the proposed computer systems is the next step. To do this requires studying the written procedures and flow charts for the proposed systems in relation to the cost tabulation for the present systems, see *Figs.* 1, 2, and 3. For each item in the tabulation, the question must be asked, "How will the cost of this item change as a result of using an automatic computer?" If the answer is "increase," then the amount of the cost increase must be estimated and recorded. If the answer is "decrease," then the amount of the saving must be estimated and recorded. If the answer is "no change" then the item is irrelevant, as pointed out earlier.

New additional costs must be included—for example, the costs for programming, air conditioning, etc., see *Fig.* 4. The net result of all these savings and cost increases combined is the saving (if any) of the proposed computer systems over the present noncomputer system, not allowing for the capital investment involved in the use of an automatic computer. Notice that the investment costs of the automatic computer, *Fig.* 4, should not be included in figuring the saving, even if a rental charge is involved. Automatic computers in the price area indicated in *Fig.* 4, include: Datatron 204, Elecom 125 with file processor, Monrobot-MU, and NCR 303. As a matter of conservatism, the unused capacity of an automatic computer is best classed as an indefinite benefit, not as a dollar saving.

▶ Interpreting the Figures

Before interpreting the net saving figure obtained from the cost tabulation, a bit of analysis is in order. As shown in *Fig.* 5, it is impossible to profit in terms of money by using an automatic computer if to do so involves both a higher investment and a higher operating cost. Also, an automatic computer is sure to be profitable if to use it involves both a lower investment and lower operating cost. It is the in-between cases that are equivocal, and that require further analysis to resolve. The case that is usually important for automatic computer systems is the case of higher investment but lower operating cost.

In other words, to interpret the net figure from the cost tabulation, the saving must be compared to the acquisition cost of the automatic computer including the conversion loss. Since the increase in profitability is the excess of the savings over the investment or amortization charges the crucial question is therefore, "Is the saving at least as large as the amortization charge covering the acquisition cost and the conversion loss?" If the answer is "yes," the use of an automatic computer will be profitable. If the answer is "no," or "breakeven," then the use of an automatic computer will not be profitable. In that case, the use will have to be justified, if at all, in terms of the indefinite costs and benefits noted earlier. To make the comparison, a proper amortization period (service life) must be estimated for the automatic computer. Normally, only automatic computers with a minimum service life of seven years should be considered. If computers of shorter service life are considered, with the present high obsolescence rate of automatic computers, it can usually be shown that those computers will not prove to be sound financial investments.

PROFITABILITY OF PROPOSED ALTERNATIVES

Investment required for proposed Alternative	Operating Cost of Proposed Alternative:	Profitability Decision
Higher	Higher	Unprofitable
Higher	Lower	Uncertain
Lower	Higher	Uncertain
Lower	Lower	Profitable

Fig. 5—A proposed installation may offer lower operating costs, lower investment costs, lower costs for both or higher costs for both

AXC CORPORATION
MONTHLY ESTIMATES

Recap of Proposed Computer Applications

Item of Cost	Computer System Increase	Decrease
SPECIFIC COSTS		
Automatic Computer Application #1	$ 65	$4455
Automatic Computer Application #2	130	3295
Automatic Computer Application #3	175	3155
Total	370	10905
GENERAL COSTS		
Salary Increases for Systems Group	200	
Programmers	800	
Operator	500	
Maintenance Technician	375	
Clerk	280	
Supplies	300	
Power for Computer & Air Conditioning	75	
Total	2530	
Total for Re-Cap	2900	10905
Estimated Monthly Net Saving from Computer		8005
Estimated Annual Net Saving from Computer		96060
INVESTMENT COSTS		
Contract Price for Automatic Computer with full set of Auxiliary Equipment including Magnetic Tape Equipment	250000	
Anticipated Conversion Loss Going from the Present Systems to the Automatic Computer Systems including Training, Programming, and Installation Costs	40000	
Total Investment Costs	290000	

Fig. 4—To evaluate dollar-and-cents feasibility, operation costs and savings for all proposed computer applications must be compared to total investment costs required to install the systems

Interpretation of the savings figure from the cost tabulation should take future obsolescence into account. In business, the measure of future obsolescence is the amount of the saving in operating cost one will lose or forego at a future time by using an automatic computer acquired now instead of a more profitable automatic computer which may become available. The history of automatic computers is short, less than ten years, yet in that time the rate of obsolescence has been very high, and it probably will continue to be high. It is very important, therefore, in answering the question of feasibility to take obsolescence into account. At

AXC CORPORATION

Comparison of Savings and Amortization Costs for Proposed Automatic Computer Applications

MAPI Formula

Assume:
7 Year Service Life
10% Interest Rate
No Terminal Salvage Value

Computation:	
Percentage Factor Obtained from *Fig. 7*	23%
Add Interest Rate	10%
Total Percentage Factor	33%
Multiply Percentage Factor and Investment Costs to obtain	$290000 x 33%
Automatic Computer Adverse Minimum	$ 95700
Present System Adverse Minimum *(Fig. 4)*	$ 96060

The automatic Computer Systems will prove more profitable.

Fig. 6—Using the MAPI formula and charging interest at 10 per cent on the investment, an annual investment cost or adverse minimum is found for the proposed computer

present, there is one simple yet fairly sound method of doing that, and that is by using the MAPI formula.

Feasibility may be determined with the aid of the MAPI formula, see *Fig.* 6. For a minimum service life of seven years *Fig.* 7 gives a 23 per cent adverse minimum for zero salvage the most conservative salvage estimate. Add to it the interest rate

the conversion loss, an amount equal to twelve times the monthly rental payments for the automatic computer (including the maintenance contract, if any, etc.). The result will be the adjusted adverse minimum for the computer systems.

Adverse minimum for the computer systems can be directly compared with the annual figure obtained from the cost tabulation in *Fig.* 4 which is known as the adverse minimum of the present systems. If the computer systems have the lower adverse minimum, it means that the acquisition and use of an automatic computer will be profitable because the increased amortization costs are more than made up by the saving in operating costs, even

Courtesy, Machinery & Allied Products Institute

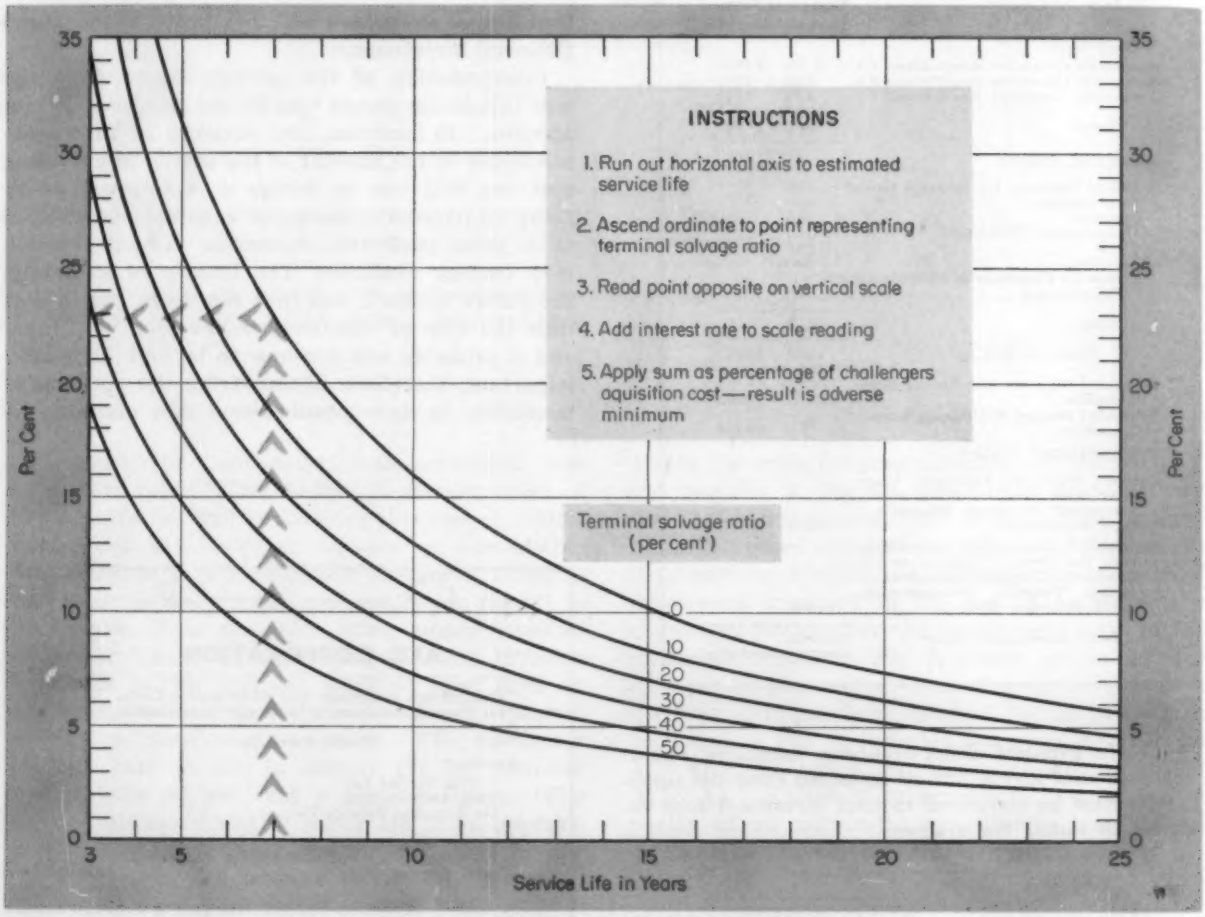

Fig. 7—Chart for deriving adverse minimum of proposed equipment by the MAPI formula

set by company policy to apply in consideration of investments in assets. The resulting percentage should then be multiplied by the total of the acquisition cost and conversion loss for the automatic computer. The product is known as the adverse minimum for the computer systems. In the case of renting or leasing an automatic computer, the adverse minimum should be figured by the same procedure but using only the conversion loss. Then, add to the adverse minimum obtained for

allowing for obsolescence. If the present systems have the lower adverse minimum, it means that the present systems are more profitable than the proposed computer systems.

For policy reasons some companies may wish to ignore obsolescence in determining automatic computer profitability. For them the MAPI formula method has little to offer. However, from the data at hand, the payoff period can be calculated in a manner that is theoretically sound—which is more

than can be said of most payoff computations! The procedure is illustrated in *Fig.* 8. After division of the annual net saving by the net investment, the resulting capital recovery factor is compared to a table of capital recovery factors for the desired interest rate, *Fig.* 9. The payoff period can thus be found. Because of the way in which the annual net saving and the net investment have been computed, any payoff period less than four years indicates that the use of the proposed systems will be profitable. The same procedure and rule apply in the case where an automatic computer rental installation is being considered. In that case the annual amount of the rental must first be deducted from the annual net saving before dividing by the conversion loss to obtain the capital recovery factor.

Features of Method

Two features of this general method of determining automatic computer profitability are important. First, the method is independent of the size of the company. That is, there is no part of the method, directly or indirectly, that makes the profitability of an automatic computer depend upon the size per se of the company. Just as some small companies may not be able to show the use of an automatic computer to be profitable, so some large companies may not be able to do so either. In large companies, simply because they have larger total costs, it is usually easier to find enough savings to bear the load of amortization, but there is no necessary relationship between the size of a company and the profitablity of using an automatic computer.

A second feaure of this general method of determining automatic computer profitability is even more basic. The savings that must bear the load of amortization arise only because of the cost differences between the present noncomputer systems on one hand, and the proposed computer systems on the other. These cost differences arise because a different way of doing things was devised for the proposed computer systems—a different way of combining the labor, the supplies, and the equipment to get the tasks done for the company.

In the proposed system shown in *Fig.* 2, a number of additional improvements appear possible. For example, the wasteful exchange filing in Purchasing, and the report "for reference" are areas of possible labor savings. The use of a TKP (typewriter-key-punch) in Purchasing could be considered as a way of eliminating the punching of master cards in Machine Accounting with a possible labor and equipment saving. The use of a magnetic tape producing typewriter could accomplish such an end and could eliminate part of the conversion operation as well. The possibility that job order accounting could be done as a by-product of some more necessary operation is an area of even greater possible savings.

Finding better ways of combining the labor, the supplies, and the equipment is known as industrial engineering when applied to work in the shop, and as systems analysis when applied to work in the office. This correctly suggests that the amount of the savings is dependent upon the quality of the systems analysis work. High-quality systems analysis can result in showing an automatic computer to be profitable even in a small company, but low-quality systems analysis work may not be able to show an automatic computer to be profitable even in a large company.

CAPITAL RECOVERY FACTORS FOR 10% INTEREST RATE

Year	C.R.F.
1	1.1000
2	0.5762
3	0.4021
4	0.3155
5	0.2638

Fig. 9—Tables of capital recovery factors, similar to this excerpt, are available. They show the number of years required to pay off an investment bearing a specified interest for given ratios of annual savings to investment costs

AXC CORPORATION

Comparison of Savings and Amortization Costs for Proposed Automatic Computer Applications
Payoff With Interest

Assume:
10% Interest Rate
No Terminal Salvage Value

Computation:
Capital Recovery Factor is found by dividing Annual Net Savings by Net Investment Costs — $96060 ÷ $290000 = 0.331 Capital Recovery Factor

Locate computed Capital Recovery Factor in a set of Tables to find Payoff Period of about 3 years 10 months

Fig. 8—Comparison of costs and savings may be made by the payoff method—a determination of the time required to pay for the investment from savings while charging interest on the investment

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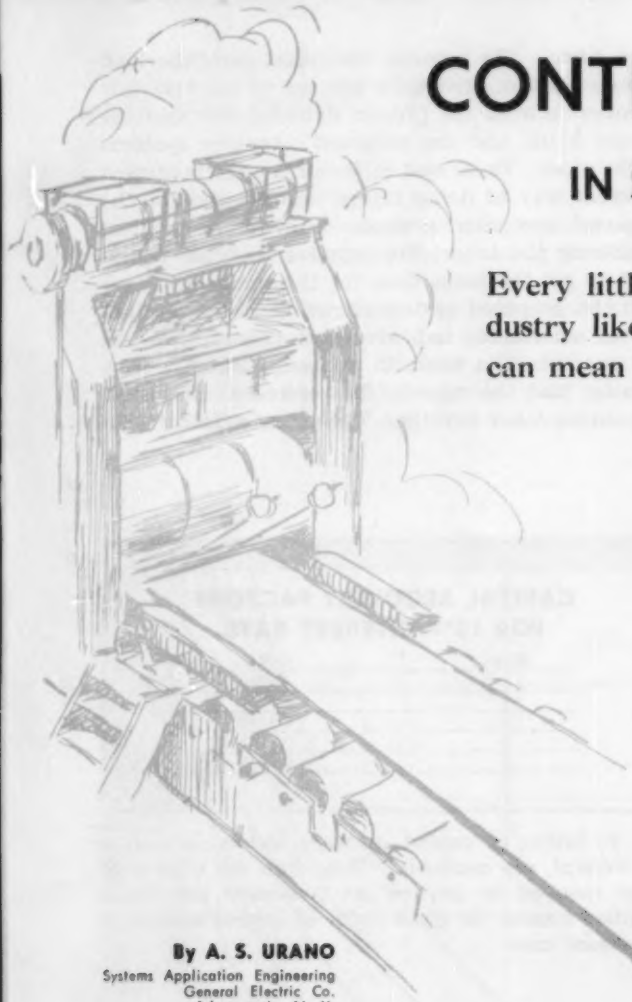
CONTINUOUS GAGING

IN STEEL MILLS PRODUCES PROFIT

Every little bit counts—and costs. In a high volume industry like steel, saving thousandths by accurate gaging can mean saving millions on yearly production



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IN STEEL, as in most other industries, the road to complete automation is an evolutionary one. Steel is a basic product used in many forms. Hot-rolled skelp is formed into pipes and tubes; billets are formed into rails, steel beams, rods, and many other structural shapes; slabs are formed into sheet steel and tin plate. All the steel for these end forms go through the same or similar steelmaking processes and primary hot-rolling metal breakdown systems. In addition, there are various cold-metal rolling and cold processing systems through which the steel passes, de-

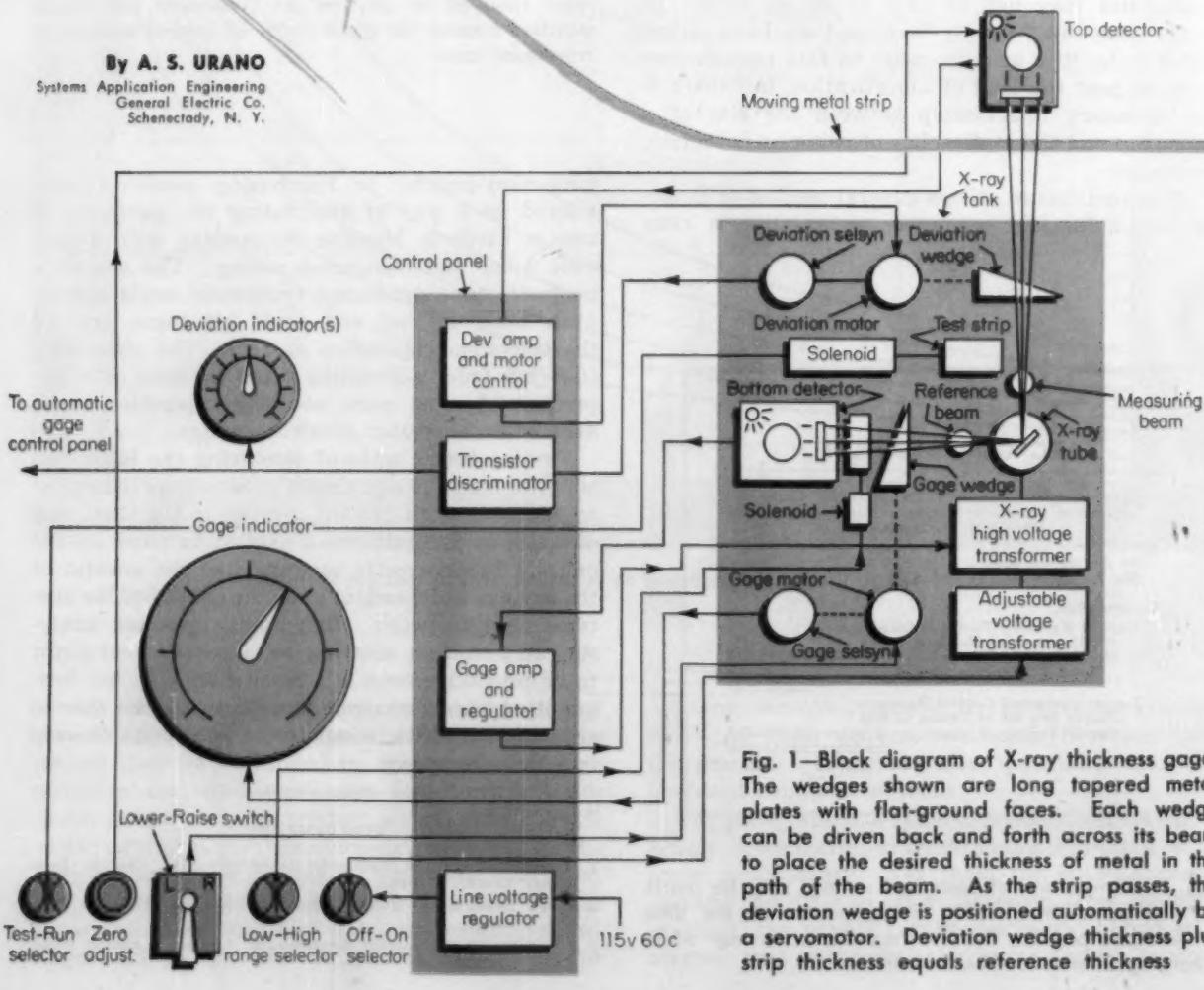

Fig. 1—Block diagram of X-ray thickness gage. The wedges shown are long tapered metal plates with flat-ground faces. Each wedge can be driven back and forth across its beam to place the desired thickness of metal in the path of the beam. As the strip passes, the deviation wedge is positioned automatically by a servomotor. Deviation wedge thickness plus strip thickness equals reference thickness

pending upon the finished product.

Because of the tremendous investment in equipment and the space involved, it is impractical for every steel plant to have continuous flow from ore to any one of the finished steel forms, rod, sheet steel, etc. Therefore, the industry is bending all its efforts towards automation in the individual steel-making, rolling, and processing systems, or combination of systems where feasible. This effort takes the form of better material handling between systems, automatic controls toward the goal of higher production, quality control and inspection of product for better production; and in the cold processing of steel, toward combining of several systems for continuous strip steel output. This discussion will be confined to automation developments in X-ray and width gages for hot-strip mills, and automatic gage control for cold-rolled strip.

Gages for Hot-Strip Mill

A typical modern continuous hot-strip mill can roll in excess of two million tons of steel a year. To emphasize the critical importance of gaging, it should be noted that as little as one per cent increase in yield can result in an increase of several million dollars worth of product out of the steel plant. X-ray thickness gages and width gages are being used on modern hot-strip mills to continuously monitor thickness and width during runs.

X-ray type gages operate on the principle that when a beam of X-rays strikes a material such as sheet steel, some of the X-rays are absorbed and some pass through the sheet. The density of the material determines the amount of absorption, and the amount of energy absorbed is an indication of density or thickness. A block diagram of a typical X-ray thickness gage is shown in *Fig.* 1. A hot-strip mill X-ray gage in its fully retracted position installed on a 132 inch wide mill is shown in *Fig.* 2.

An X-ray thickness gage now makes possible continuous production of strip by continuously and accurately indicating within ± 0.3 per cent of full scale reading, the deviation of strip thickness from the required thickness as it leaves the last hot-rolling stand. With a continuous record, it is an easy matter for an operator to observe the trend of deviation and make the necessary speed or screwdown adjustments. In the near future, perhaps, as in tandem cold-strip mills, such gages could possibly be used in an automatic gage control system.

Another measuring tool, the photoelectric width gage, is being used in hot-strip mills. It is a non-contacting device that continually and automatically measures the width of hot-strip steel to an accuracy of 1/16-inch, independent of limited lateral or vertical motion. As shown in *Fig.* 3, two phototube scanners mounted 15 feet above the hot steel sense the infrared rays radiated from

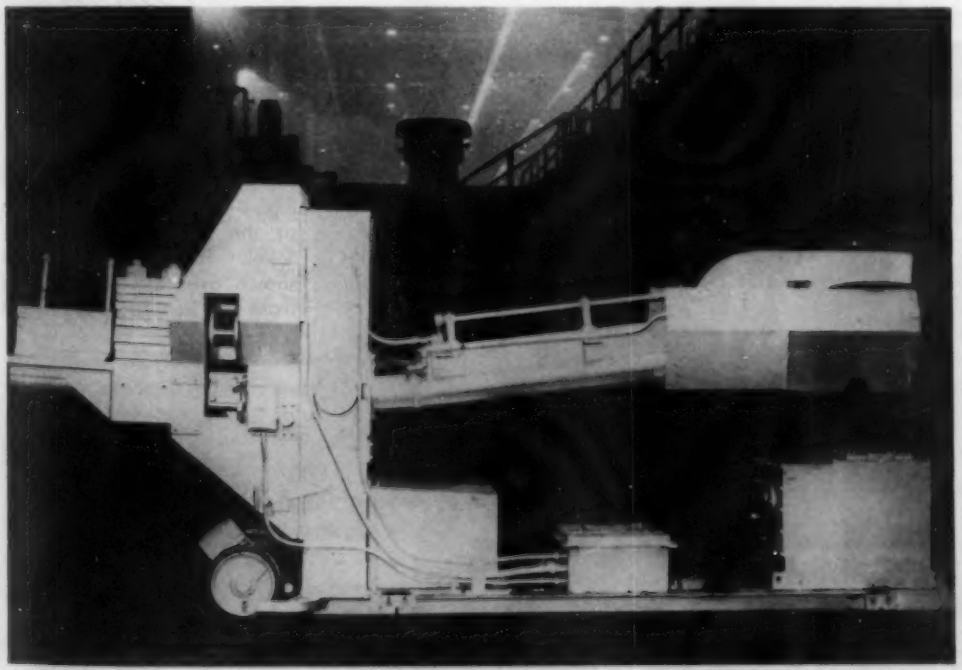

Fig. 2—X-ray thickness gage installed on 132-inch plate and strip mill. Motor driven truck is in fully retracted position. When in operation, lower portion is under mill runout table. An X-ray beam passes upward through moving hot strip to the detector at the end of the counterbalanced arm. This instrument is installed at the Geneva Steel Co. in Geneva, Utah

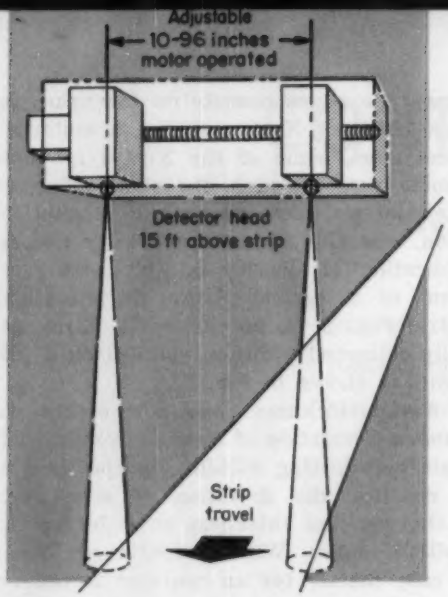

Fig. 3—Width gage for continuous hot strip mill. Infrared rays radiated from the strip are sensed by two phototube scanners mounted above strip edges

the strip and convert the rays into electric signals. Resulting signals are amplified and used to determine deviation from the chosen gage setting.

Position of the two scanning units located inside the detector is adjusted by a motor driven screw, which is controlled from the operator's control cabinet and which places the two scanning units directly above the nominal position of the edges of the strip. Scanning is provided by a rotating slotted disk which repeatedly sweeps across the image of the strip edge at right angles to the direction of strip travel. Each unit scans approximately 5 inches to 10 inches off the strip and 5 inches on the strip. This overscan allows for limited sidewise motion without introducing appreciable errors.

Signals from the scanning units are used to produce, through electronic amplifier and control circuits, rectangular pulses which vary in width but not in amplitude—amplitude is fixed and the pulse width is determined by the position of the steel strip edge. These two sets of square waves, each representing one strip edge, are added and the sum is used to obtain a dc voltage dependent only on the variation of strip width. By means of a bridge circuit, this voltage is used to indicate the actual strip width deviation on a meter or recorder.

When the steel is the correct width, output from the two circuits results in a zero deviation signal. Sidewise motion of the strip will increase the pulse width from one scanning unit and decrease that from the other unit; the sum of the two will remain constant.

Strip widths of from 10 to 96 inches can be measured with temperatures approximately 1250 F and indicated in less than one second after the strip passes under the phototube detectors. Strip position can change as much as 3 inches either vertically or horizontally without materially affecting gage accuracy.

With such a gage to continuously measure strip width, the actual width can be kept to close tolerances by proper adjustments by the operator. For a mill rolling two million tons of steel per year,

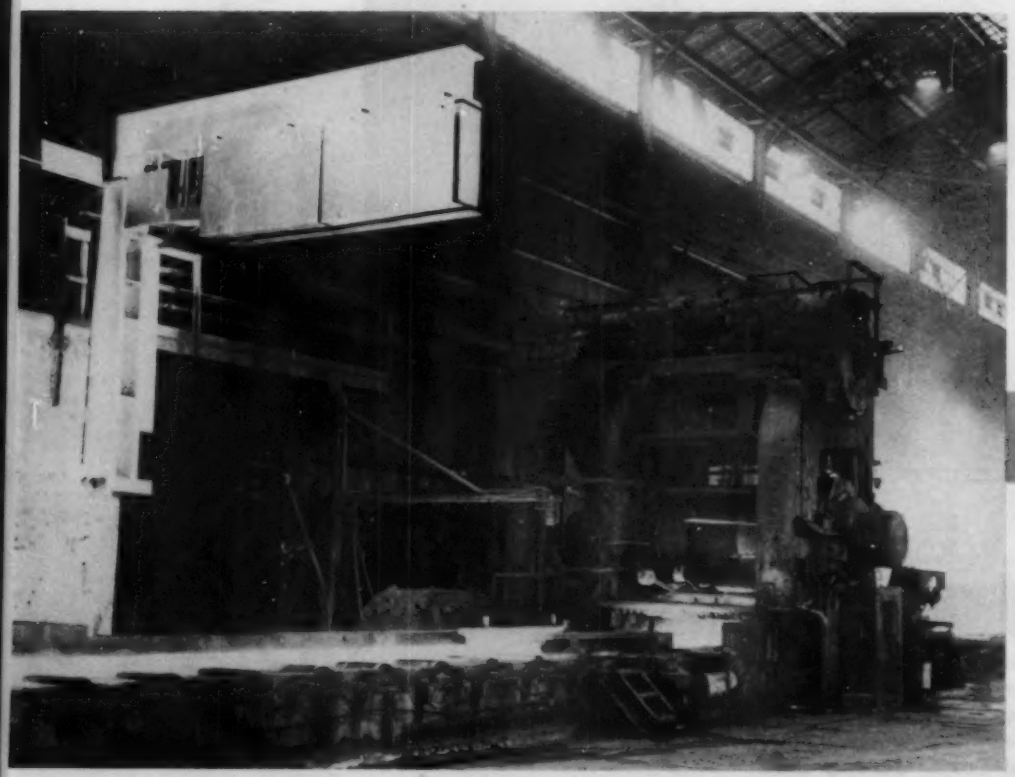

Fig. 4—Steel mill width gage at the Irvin Works of U.S. Steel. The detector head is shown over the strip coming from the last roughing stand

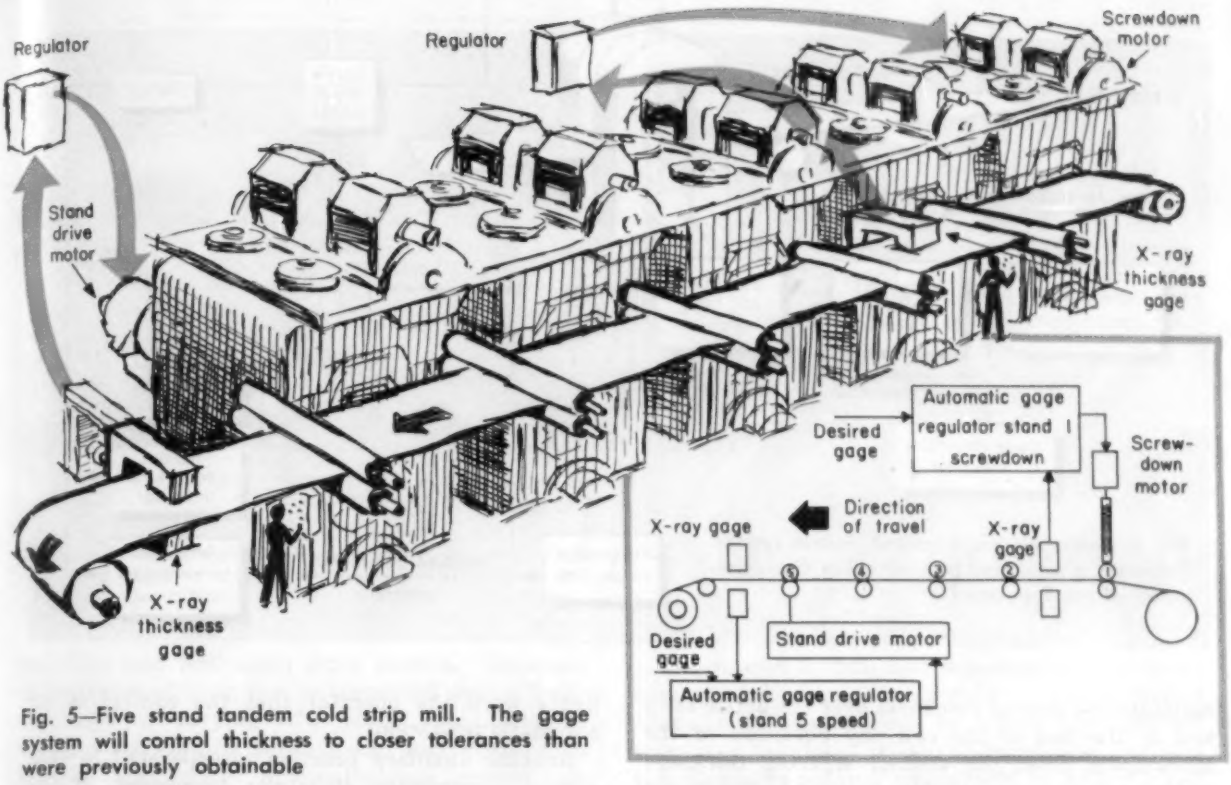

Fig. 5—Five stand tandem cold strip mill. The gage system will control thickness to closer tolerances than were previously obtainable

holding strip width to ⅛-inch closer tolerance would convert 8000 tons of steel per year from scrap to finished steel at a saving of over $200,000. An actual installation of a width gage following the last roughing stand on a continuous hot-strip mill is shown in *Fig.* 4. This is an unusual installation since, as a rule, the width gage is located after the finishing stands to monitor the width of the finished hot-rolled steel.

▸ Cold Strip Gaging

Several automatic thickness gage controls have been in service on tandem cold-reduction mills which operate on screwdowns of only the first stand, taking thickness signals from either X-ray or Beta-ray gages. Recently, an automatic gage control system, *Fig.* 5, placed in operation on a tandem cold-strip mill at the U. S. Steel Irvin Works, will control thickness to a tolerance of ±0.0001 inch. This automatic gage control system includes a complete complement of auxiliary functions integrated with the overall drive system to reduce manual operations to a minimum. The automatic control consists of two sections, a coarse system operating on the screwdowns of the first stand, and a vernier system controlling the speed of the fifth stand to change tension between stands four and five. The regulating systems themselves were designed utilizing transistor and magnetic amplifier techniques and components, and use no vacuum tubes. The General Electric Co. and United States Steel Corp. co-operated in development of the systems as a joint project.

In the coarse system shown in *Fig.* 6 an X-ray gage is mounted between the first and second stands to measure strip thickness out of the first stand. The desired thickness is set on the gage as a reference signal. The difference between actual thickness and desired thickness is indicated by the gage as a deviation or error signal. This signal is fed into a transistor discriminator circuit which determines the direction of the error—whether it is heavy or light. The polarized signal is fed into *On* and *Off* time circuits containing amplistats.

The *On* time circuit is designed such that the *On* timing is proportional to the magnitude of error signal. In other words, if the strip coming out of the first stand were ½-mil off-gage, the screwdown motors would run for a shorter time than if the strip were 1 mil off-gage. This type of operation requires the screwdown motors to run less frequently to bring thickness back into tolerance than if a constant *On* time were provided. The *Off* time circuit is provided to permit the strip to travel from the rolls of the first stand to the X-ray gage position before the regulator makes any further operation on the screwdown motors. Several auxiliary functions are incorporated in this coarse regulator such as automatic *Screw-Reset, Screw Departure Indication, Screw Departure Limits,* and *Regulator Inspection.*

Most off-gage material supplied to a cold-reduction mill occurs at the beginning and end of the coils. The operator will select a normal screw opening which will give him on-gage tolerance during mill start-up. The automatic gage control will

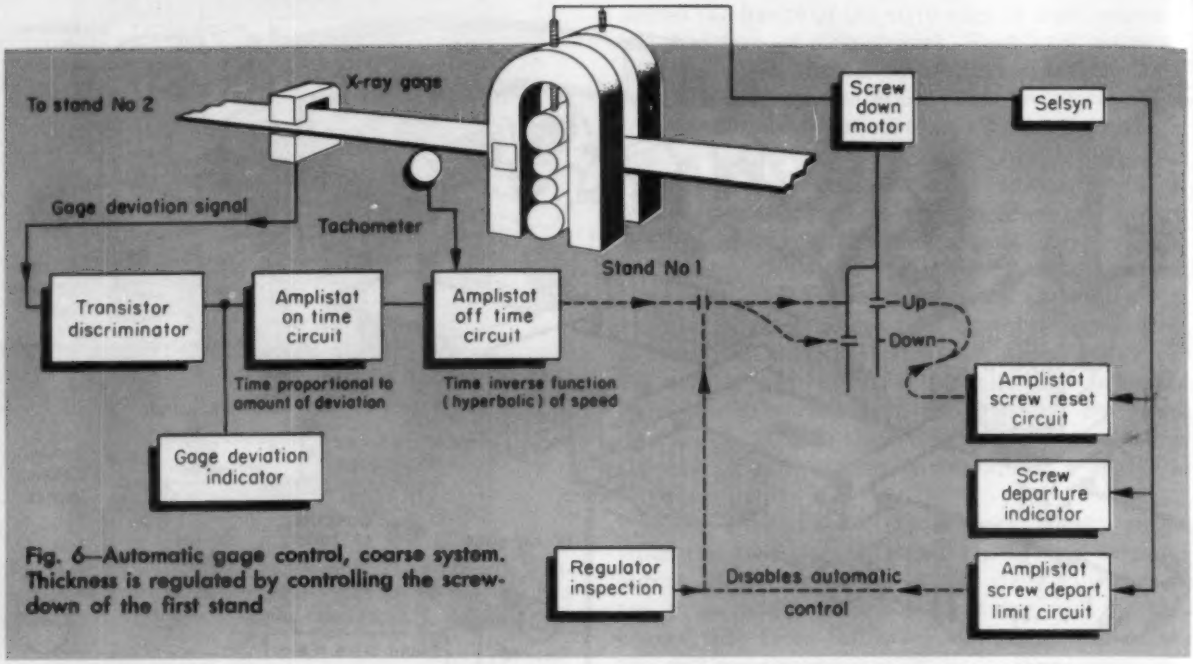

Fig. 6—Automatic gage control, coarse system. Thickness is regulated by controlling the screwdown of the first stand

maintain the desired thickness over the entire strip and at the end of the coil any deviation of the screwdowns from the desired entering thickness setting will be automatically removed by the *Screw Reset* circuit which will run the screwdowns back to the original setting made by the operator.

The *Screw Departure Indicator* is a meter which indicates to the operator how far the screws have departed from his original setting. There are times when the automatic gage control might move the rolls either too far apart or too close together which would produce improper rolling. If the screws open too wide slippage will occur; if the rolls come too close together, the stand motor might become overloaded and shut down the operation. The *Screw Departure Limit* circuit prevents this since it disconnects the automatic control when preselected limits are reached. At the same time lights warn the operator that the control is off automatic operation.

Another auxiliary function incorporated in this control is automatic *Regulator Inspection*. If the regulator does not reduce thickness error during a preselected time limit, it is removed from operation, and again the operator is warned by a signal light.

Vernier Gage Regulator

The coarse gage regulating system is designed to reduce large thickness variations. Remaining small thickness variations are further reduced by the operation of the vernier regulator shown in *Fig. 7*. The system is integrated into and works through feedback control systems associated with

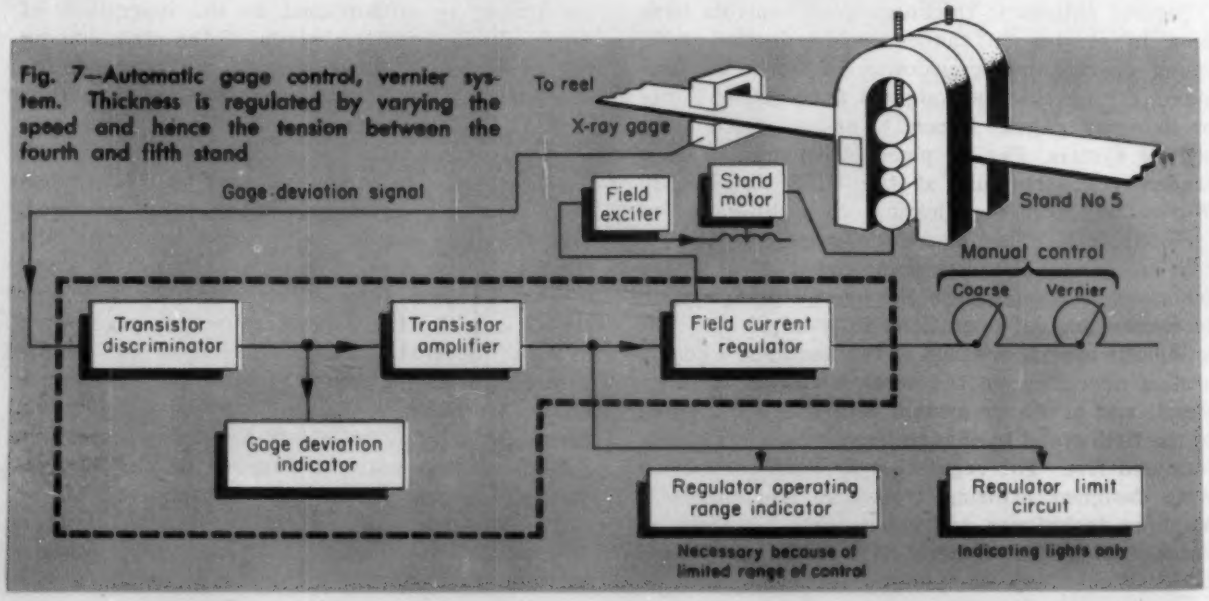

Fig. 7—Automatic gage control, vernier system. Thickness is regulated by varying the speed and hence the tension between the fourth and fifth stand

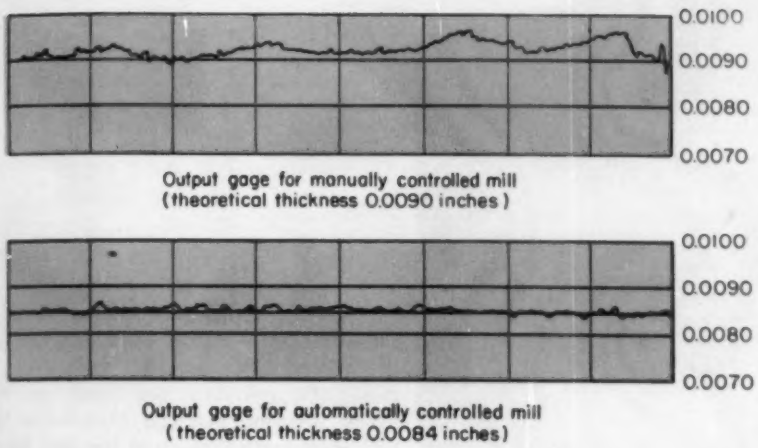

Fig. 8—Charts of gage control, manual versus automatic control. Top chart shows the variation in thickness with the automatic gage control system turned off. The lower chart shows finished gage variation in thickness with the automatic gage control system in operation

the fifth and last stand drive system. Thickness of the finished strip can be controlled over a limited range by varying fifth stand speed, thereby varying the tension between the fourth and fifth stands. The vernier automatic gage control system uses this principle to control the final gage of the steel strip.

An X-ray gage similar to the one used between the first and second stands measures the thickness of the strip leaving the fifth stand. Here again the desired thickness is set on the gage as a reference signal. This is compared with the thickness of the steel actually coming from the fifth stand and a signal proportional to the difference is fed into the automatic gage control circuits as a deviation or error signal. The deviation signal is again fed into a transistor discriminator which determines polarity of the signal. The polarized signal from the discriminator is amplified by a transistor device to a power level suitable for the motor field current regulator. Networks are incorporated in the transistor amplifier circuit to stabilize the operation of the regulator when controlling thickness.

In actual operation the fifth stand is set up by means of the screwdowns and coarse and vernier settings of the motor field current regulators to approximate the desired output thickness. The automatic gage control then operates to control the speed of the fifth stand.

The vernier system also has auxiliary functions incorporated. Since the regulator has a limited range, provision is made to inform the operator when the regulator is out of range and requires the necessary manual adjustment of either screw setting or of coarse or vernier speed control. This function is provided in two ways, one by means of a regulator *Operating Range Indicator* which is mounted on the operator's cabinet and consists of an indicating meter calibrated from minus 3 per cent to plus 3 per cent speed departure. As long as the meter indicates within this range the operator has no particular problems. The automatic control will regulate the gage automatically. However, if the meter indicates to one end of the scale and stays there, the *Regulator Limit Indicator* signals the operator that the regulator is out of range and that manual adjustments must be made on the fifth-stand control. Inspection functions similar to the coarse regulator are included to protect against malfunctioning of system components.

A chart of system performance of manual versus automatic control is shown in *Fig.* 8. It is entirely possible for an alert operator to manually control within closer limits than those shown on the manual control chart. However the automatic gage control can control continuously and automatically, and the human element "possible" is eliminated, another forward step toward fuller automation.

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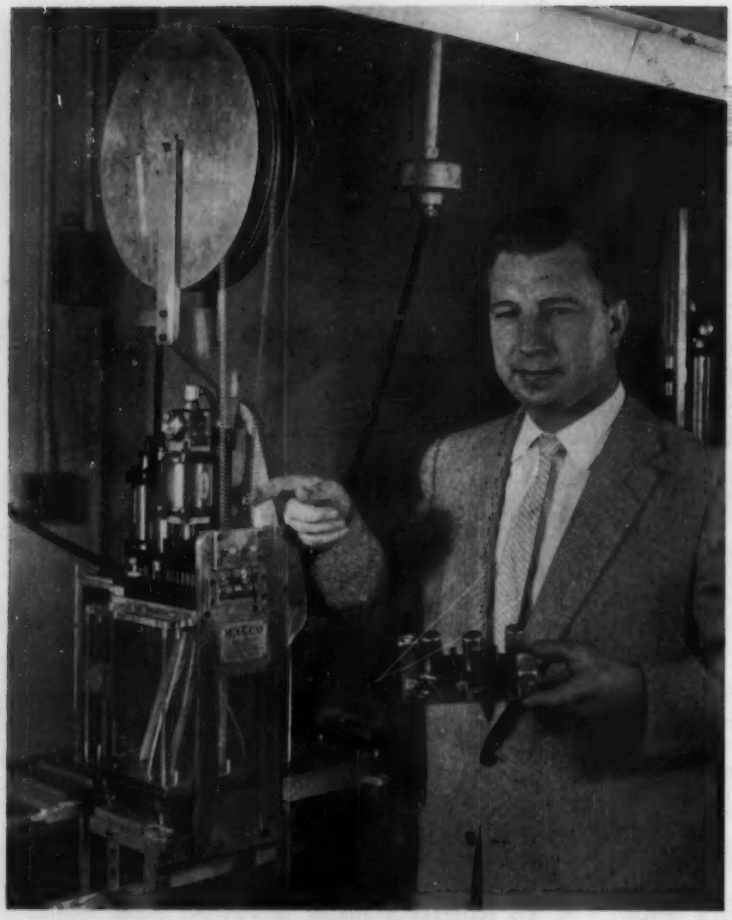

Fig. 1—The author pointing to strip of self-retaining terminals used in assembly of printed TV circuits. Bellows Co. pneumatic cylinders are used on the Malco inserting machine to actuate the reel feed mechanism and the pin forming and cutoff operations.

By PAUL MAXIMOFF
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FLEXIBILITY IN AUTOMATED CIRCUIT BOARD ASSEMBLY

Cost-price squeeze has induced the electronics industry to adopt automatic assembly of circuit boards. But what about tooling changes for alternate products? Here is a packaged solution that reduces retooling to changing of templates.

DEVELOPMENT of "printed circuitry" has opened the door in the electronic industry to new and faster manufacturing techniques, highly improved production methods and the reduction of human error—in short, opened the door to automation. This new form of electronic circuitry was readily adaptable to mass production assembly and soldering techniques. Special circuit components have been introduced to facilitate terminal connecting.

Among the first developments in circuit board production hardware was the Malco miniature

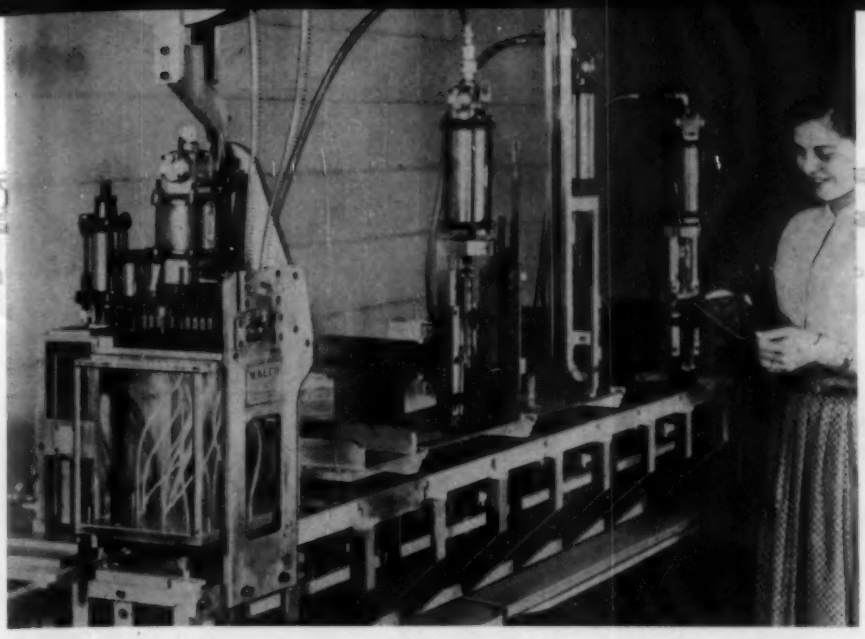


Fig. 2 — Mechanized circuit board production line at Admiral Corp. In foreground is the machine that inserts up to 40 self-retaining pin terminals and contacts within 3 seconds. Immediately following are other automatic stages contributing toward complete assembly.

self-retaining tubular pin terminal, *Fig.* 1. This terminal is designed so that two beads on the lower part of the pin terminal depress and snap out when inserted in the printed circuit board, locking it in. Not only does this eliminate roll-over operations, but it permits insertion of "pig-tails" into receiving holes in the terminals at either the top or bottom of the board. Flanging the bottom hole of the terminals allows additional wrap-around connections.

Companion to this pin terminal is a female contact which fits onto the top of the tubular pin for quick connect and disconnect applications. Wire wrap terminals for use with wire wrapping machines have also been developed.

Obviously, manual insertion of these terminals would be both tedious and time consuming. However, by producing them in strip form, coiling strips on reels, and using automatic insertion equipment, the operation becomes fast, accurate and completely automatic. This technique was applied in the development of the Malco automatic pin and contact inserting machine, along with equally automatic crimping equipment and staking equipment for the wire wrap type terminals *Fig.* 2. Most important of these is the machine which inserts up to 40 terminals in 3 seconds, turning out 1200 complete circuit boards per hour.

Tubular pin type terminals in continuous strip form are fed from two reels, threaded through rollers, and passed through a die where they are automatically formed and severed from the carrying strip, *Fig.* 3. They are then deposited in individual plastic tubes, which are arranged into any pattern the printed circuit board may require. The tubes and jig-bored template are enclosed in a plastic and aluminum pattern box which can be quickly removed from the machine and replaced with another when the circuit pattern is changed.

The printed circuit board is raised by a platen to register against the pattern box. After the pins have fallen into their respective holes in the

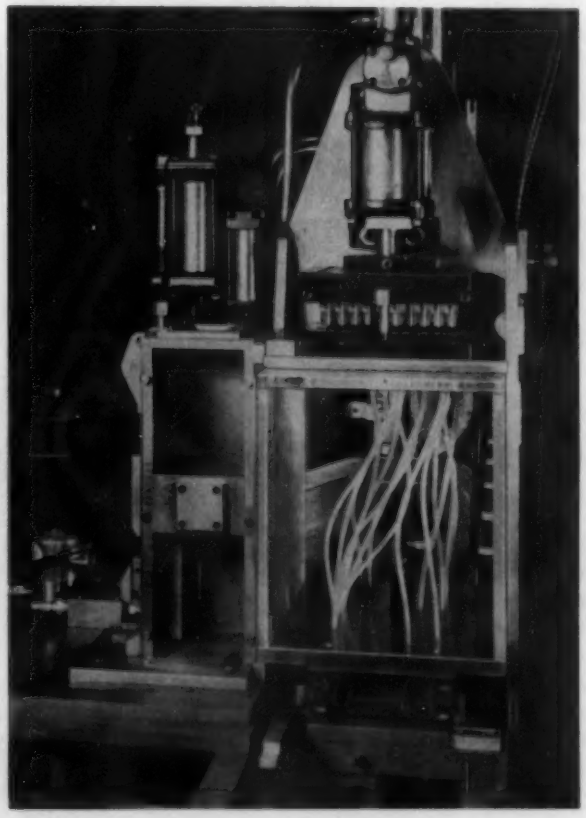


Fig. 3—Automatic pin and contact inserting machine, showing cutoff and feeding mechanism and tubes through which terminals are dropped into the circuit board.

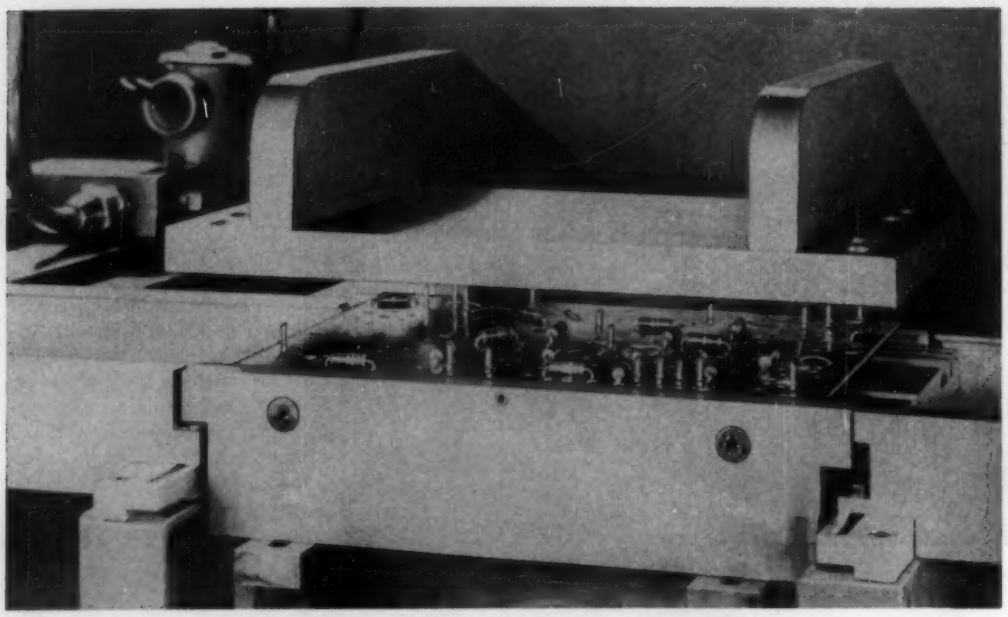


Fig. 4—Close-up of circuit board in the terminal-seating station. The board is raised against the template shown which forces the terminals to snap into location.

template, a vibrator is actuated, nesting the pins into the board.

When the platen recedes to the transfer position, the roll of strip with pins attached is automatically advanced for a repeat cycle. This feed portion of the machine is pneumatically operated and designed for quick replacement in the event of malfunction. Construction is based on a gear and rack principle—the rack carries two feed pawls which are cammed individually to feed any desired number of pins by registering and locking the cam bar in line with graduations on the plastic faceplate. Ribbon scrap is also cut in this section of the machine for efficient handling.

After the terminals have been nested in the circuit board, the transfer mechanism moves the board to the second stage of the operation where another platen raises the board against a template, snapping the terminals into the board, *Fig.* 4. This template has funnel shaped inserts which guide the pins during the snap-in process.

Transfer and handling of boards through the Malco machine can be accomplished either by rails or pallets normally used in automatic component assembly machines or they can be engineered to meet individual applications.

One leading radio-television manufacturer, using the Malco inserting machine in conjunction with other automatic assembly equipment, has eliminated over 400 hand soldered connections and inserts over 70 per cent of the components automatically. Adoption of methods similar to these will be industry-wide within the next few years.

As is always the case with progress such as this, a need for skilled technicians and precision machinery has been created. While an article of this nature is not primarily concerned with this aspect, it should be briefly mentioned. Since the manufacturer can produce more for less and is passing it on to the consumer as such, employment is increasing—not decreasing—as production strives to meet greater consumer demand.

CARBIDES IN NONMACHINING APPLICATIONS

CEMENTED carbide components or inserts are valuable adjuncts to modern high-speed packaging and handling machines. Increased operating speeds in this type of equipment result in development of wear spots with corresponding loss of calibration in critical locating and spacing elements. Strategically placed carbide components will often add immeasurably to the economic value of this type high-speed production equipment.

When selecting a grade of carbide for a special application which requires maximum wear resistance, the hard, fine-grained, low-cobalt binder material appears to be a logical choice according to engineers of the Carboloy Dept. of General Electric Co.

One of the outstanding properties of cemented carbides is compressive strength. They are capable of absorbing, with minimum deformation, high compressive loads repeatedly applied over long periods of time.

BALANCING OPERATIONS AUTOMATED

BALANCING of rotating parts is a two-phase operation—inspection to determine the magnitude of unbalance and machining to correct the unbalanced condition. These operations can be co-ordinated through automation.

A connecting rod precision balancing machine that handles a variety of heavy-duty and diesel engine connecting rods has been developed by Snyder Tool & Engineering Co. The machine, *Fig.* 1, is made up of three individual units: A milling machine having two opposed double-spindle heads, a console containing all operating controls and a precision weighing unit.

To balance a connecting rod, the unbalanced rod is first placed on the weighing unit. As a result of the weighing, part-finder fingers on the milling machine are set automatically to within 0.001-inch for removal of the correct amount of balancing stock from lugs provided on the piston and crankshaft ends of the forging.

When the part-finder fingers are set, the rod is manually removed from the weighing unit and placed in a fixture on the milling machine. Pushing a cycle button in the console causes the fixture to retract between the milling heads while simultaneously clamping the rod. Both heads advance until the part-finder fingers contact the rod ends. Then the heads are locked in correct milling position to remove necessary excess material from each end. The fixture feeds forward, first past one set of rough milling cutters and then past a second set of finish milling cutters. The weighing operation for another rod is performed during the milling operation.

Two sets of milling cutters are provided to divide the amount of balance stock removal which tends to increase as forging dies wear with usage. The milling cutters are inserted tooth carbide type. This machine can be adapted to balancing of a wide variety of heavy-duty connecting rods. Only a fixture and clamp detail need be changed to mount different rods in the milling fixture. The weighing scale is individually calibrated to accommodate different sized rods.

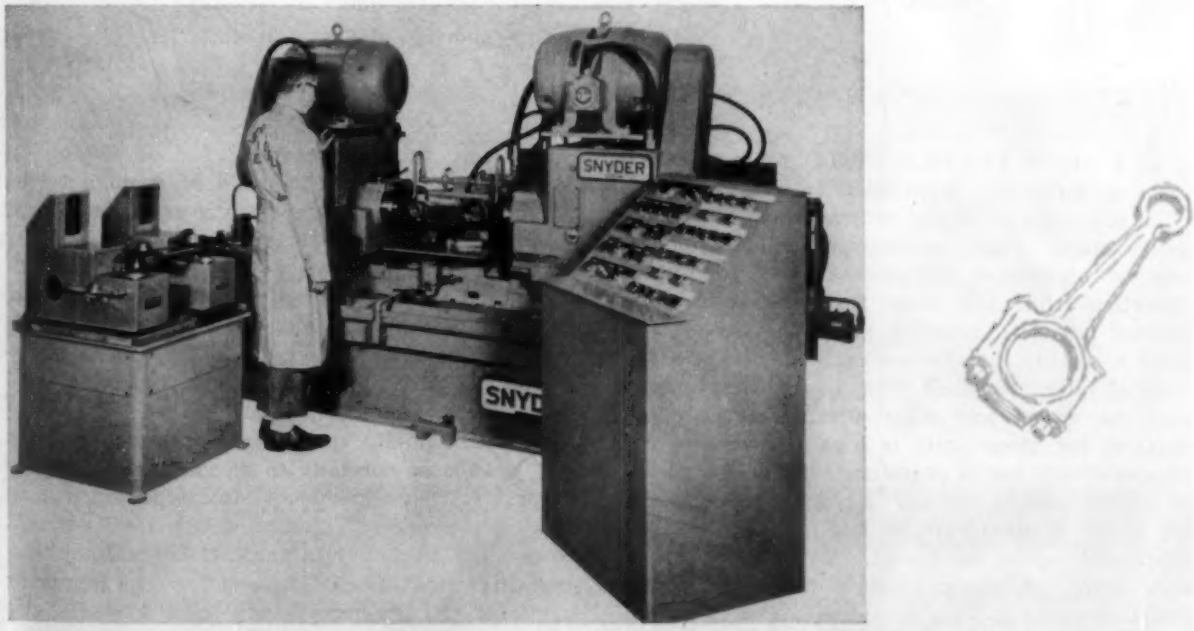
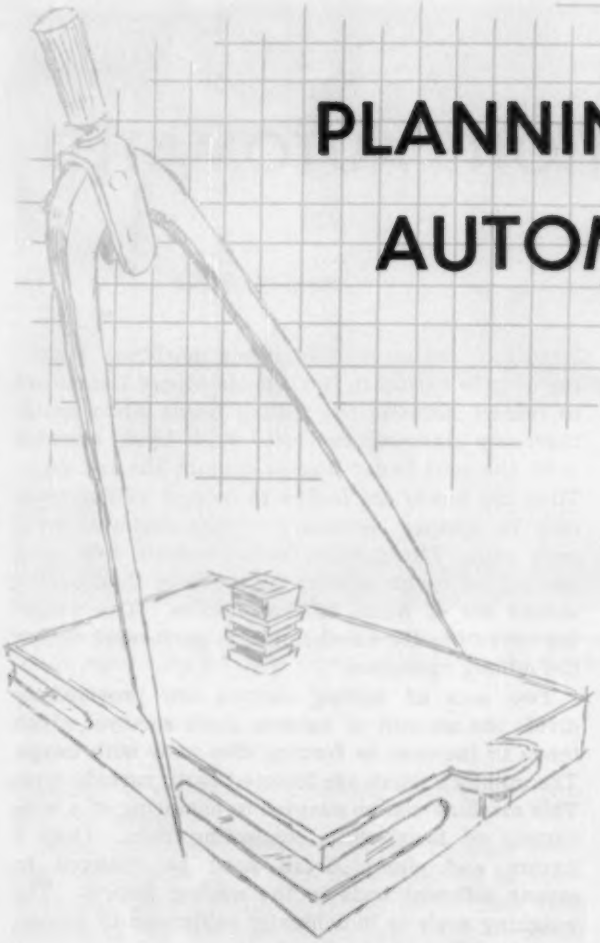


Fig. 1—Balancing machine for heavy duty and diesel engine connecting rods, ranging from 7⅜ to 12½-inch center distance. All head and fixture movements are hydraulically controlled. Maintenance for the electrical controls is simplified by utilizing packaged electronic units.

PLANNING AN AUTOMATIC PLANT



By L. V. WISE
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One of the most important steps in following up an executive decision to make a product is to plan and develop the means to produce it. Pennies wisely spent in this stage frequently mean savings of dollars during production of the item. This article describes some of the work done to make possible large-scale manufacture of quartz crystal units previously available only from laboratory type operations. Additional complication of the problem is military usefulness of the product and the requirement that production must be readily stepped up with inexperienced workers during an emergency.

A MOST FERTILE FIELD for application of automatic equipment to manufacturing processes is in the critical area of military mobilization. Many military production problems can be eliminated by process developments in peacetime which will insure fast build-up in emergencies without excessive peacetime inventories. Such a military production problem exists in the field of quartz crystals, *Fig.* 1, a critical component for radios and other electronic gear. The demand for these units is high in wartime and comparatively low in peacetime. Thus, in a period of mobilization, a demand is placed on the industry which it cannot absorb due to lack of skilled labor and capital equipment. Without the necessary supply of quartz crystals, the armed forces find themselves lacking operative electronic equipment so vital to successful modern warfare. This proved true at the outset of both World War II and the Korean conflict.

To meet this problem, the Signal Corps has given Bulova Research and Development Laboratories Inc. the responsibility for developing an integrated pilot plant capable of manufacturing 200,000 crystal units per month on a single-shift basis using a mechanized process. Two military crystal types required in large quantities, the CR-18/U and CR-23/U Crystal Units, *Fig.* 2, are to be produced. This plant would be set up on a stand-by basis in peacetime, and would be operated on a production basis only in time of full scale military mobilization.

To put it mildly, quartz crystal production does not yield most cordially to mechanization. These crystal units are frequency standards which must meet a tolerance of plus or minus 0.005 per cent of nominal frequency throughout the military temperature range of −55C to +90C. The frequency range of the program covers from 4 megacycles to 54 megacycles, and the order board for a typical month might consist of 200 different orders, each for a different frequency, ranging in quantity from 10,000 units per order down to 100 units per order. The blanks are less than ½ inch in

diameter and their final thicknesses range from 0.0039 to 0.0166 inch. They are as fragile as glass, and must not be chipped or cracked. They must be cleaned so well that it is common practice to scrub each blank by hand with a toothbrush. The thought of manufacturing these units at the rate of 10,000 per 8-hour shift was rather disturbing at the outset, but the impossibility of predicting future military needs and stockpiling such a supply indicated that improving production facilities was the only feasible approach to the elimination of this bottleneck. Specific objectives were:

1. To cut the delay time between receipt of orders and delivery of large quantities of CR-18/U and CR-23/U crystal units.

2. To reduce the drain on the nation's skilled manpower resources and quartz supplies during an emergency.

3. To increase the quality reliability of the product by using standardized, automatically controlled processes.

4. To increase and integrate the general store of knowledge on crystal manufacture and put to practical use development gains made in recent years but not yet widely used in production.

Clearly, the purposes outlined are quite different from the purposes behind a development program sponsored by an industrial concern. In such a case, the emphasis is generally an economic one, with a specific cost reduction goal being the paramount consideration. However, Bulova has added an additional goal to those listed—namely, that the cost of the crystal units manufactured by the plant under development shall be at least competitive with the rest of the industry, and that this cost shall include writing off the entire engineering and development costs as well as the first cost of the plant itself over an assumed period of five years at rated production. All indications up to the present time are that this goal will be met.

▶ Basis for Solution

Immediately after the contract was initiated in September 1954, a systems group was established to insure that the individual machine designs would be co-ordinated, and to guarantee the quality of the final product. A study was undertaken to establish an integrated development program which would fulfill the program's stated requirements. The study covered existing manufacturing processes and their adaptability to mechanization, and, where existing processes did not seem adaptable, investigated alternative methods. As a result of this study, the following rules were established for the development program:

1. The plant shall consist of individual machine units for the various operations, rather than a continuous automatic process. In this way, if mobilization were required before the pilot plant was completed, there would be some mechanized processes which could be used by the rest of the quartz crystal industry. As no skilled labor is required for the movement of material in process, mechanized material handling will be used only where economically justified.

2. Skilled operators shall be eliminated wherever practical from an engineering point of view, without requiring economic justification in each individual case. A process shall be said to require no skilled labor if each operator can be fully trained in less than two weeks.

3. Assuming the skilled operators to be eliminated from a process, the decision between one piece of

Fig. 1—Quartz crystal units such as this are important components for electronic equipment, and are used principally as frequency control devices in mobile communication gear.

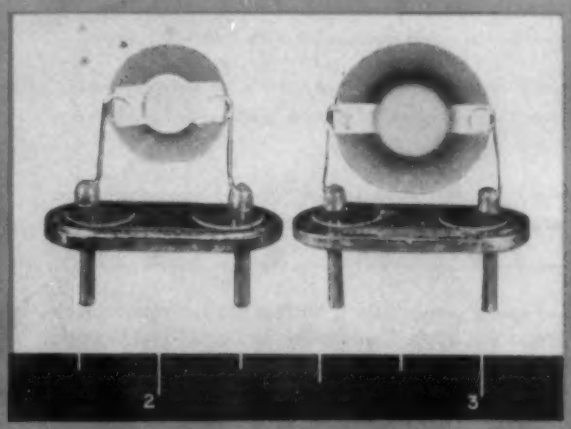


Fig. 2—With protective cans removed, CR-18/u and CR 23/u crystals look like this. The quartz blanks may be either 0.490 inch or 0.375 inch in diameter, and will vary in thickness from 0.0039 inch to 0.0166 inch over the frequency range from 4 to 54 megacycles.

Item 16: X-Ray Sorting - Process S

Process: Circular blanks with a flat will be received. ZZ' orientation of the blanks will be measured by X-ray diffraction, and the blanks will be sorted in two minute increments.

Possible Methods: The X-ray Sorter may be loaded either by hand or automatically, using either pre-loaded magazines or direct loading. The blank will be mechanically rocked to detect the reflection with the X-ray detector, which may be either an ionization chamber, Geiger counter, proportional counter, scintillation counter or cadmium sulphide cell. If the output of the detector is a series of pulses, either integration or counting techniques may be used. Measurement of the orientation can be made either with the blank in motion or stopped at the angle of maximum reflection. A two-crystal system will be used to obtain a measurement accuracy of 0.1 minutes. Preliminary tests indicate a beam width of approximately one minute can be achieved if the blank has been properly etched. Sorting will be automatic.

Unresolved Problems: The process of x-ray detection must be investigated because its action is largely statistical, and information is needed on speed of response. The response of the x-ray detector will influence the choice of system to be used, and in addition determine the maximum rate of sorting blanks.

Future Action: Investigate operation of the above mentioned x-ray detectors and build a breadboard unit of the entire x-ray sorter.

Present Visualization of Process: A completely automatic X-ray Sorter is visualized. The machine will be magazine loaded. The crystal blanks will automatically be fed into the machine, measured, and sorted into bins or magazines.

A two-crystal system of x-ray diffraction will be used to obtain maximum sensitivity and accuracy. The blank will be rocked at a rate of about one cycle per two seconds. The reflected x-ray beam will be detected with a proportional counter, and the pulses will be integrated. This signal will operate electronically one of a series of gates, depending on the position of the rocking table at the instant of maximum signal. The position of the table will be measured while the table is in motion by a simple optical-electronic system. The blank will be ejected into the correct sorting bin, opened by the action of the electronic gates.

One crystal blank will be sorted on each sweep of the table. Therefore, the machine will sort crystals at a rate of approximately one every two seconds.

No operator is required, but an attendant will empty the sorting bins and store the sorted crystals for future lapping, or correction if required."

Fig. 3—Typical page from a System Study Report which was prepared as a foundation for subsequent work. The report discussed each processing step individually and attempted to establish a plan of action and a good guess as to the result of later engineering effort.

equipment with full plant capacity, or several machines totaling full plant capacity will be made on the basis of economy, reliability and maintenance considerations.

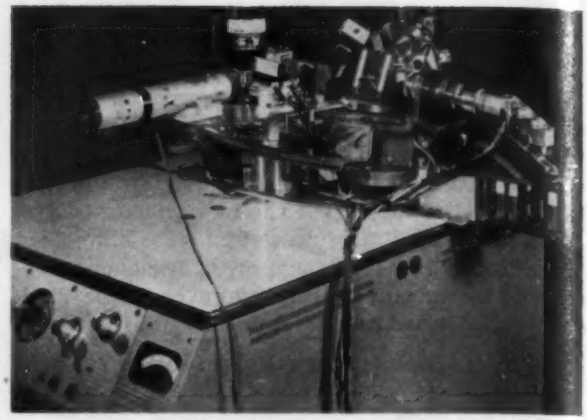


Fig. 4—Experimental model of the x-ray sorter. This machine uses x-ray diffraction methods to measure automatically the angle between the surface of the crystal and the atomic planes within the crystal. This angle (the Z-Z' angle) controls the temperature coefficient of frequency of the crystal.

4. The study found that almost no existing equipment could be utilized in the pilot plant. A rule was established that existing equipment should not be modified and used unless it would fit smoothly into the overall mechanized process. Thus, plant integration was placed above expediency. This decision has had happy results. The extra engineering effort required to design the new equipment has in general paid off with improvements far beyond those which could have been obtained by merely modifying existing equipment.

5. On the other hand, no process not now used in the quartz crystal industry shall be considered for the mechanized plant unless the proposed use for that process is well within the state of that art, and it is clear that success will be achieved. Research into new processes is, in general, beyond the scope of this program, and must be left to special programs designed to investigate them. A few new processes, such as ultrasonic dicing, have fulfilled the requirements of this rule and are being incorporated into the mechanized plant.

6. Wherever possible, skills of other organizations besides our own shall be utilized. Any section of the program shall be subcontracted where another company can do a better job than we can ourselves, and where we can utilize the developments of other government-sponsored industrial preparedness programs. As no one company can be expert in all the fields that such a broad program as this touches upon, the rule is almost one of compulsion rather than choice. but stating such a rule explicitly helps to re-emphasize it for engineers engaged in the program, some of whom are imbued with today's popular do-it-yourself fad. Where we decide to subcontract work which includes design, such tasks are closely co-ordinated with the rest of the program, both by carefully prepared specifications and by continued consultation with the subcontractor. Poor control over a subcontracted work can ruin the integration aspect of the development, one of the great advantages of a broad mechanization program.

In addition to these general guide lines, the

initial study resulted in a specific outline of a manufacturing process for the plant; one in which many methods differ from those standard in the industry. In fact, starting from scratch as we were, we also used the opportunity to redesign the product to fit the best manufacturing process. Freedom to modify the product design is often extremely important to the automation engineer. A product well suited to other production methods is often ill-suited to automatic operations, whereas some slight design change is all that may be required to make significant manufacturing improvements possible. The design change most obvious to the eye is the flat edge on the otherwise circular crystal blank, *Fig.* 2. This flat gives us the opportunity at three important stations to orient the blank automatically, where previously an operator had to do this by optical means. Furthermore, the blank with the flat is produced by a method simpler than the standard methods used to produce the circular blanks. Other design changes not apparent to the naked eye helped to simplify the individual process requirements, and ease the design task.

Process Developments

It would not be possible here to outline the entire manufacturing process chosen for mechanization and the ways in which it differs from the standard process. However, one example should indicate the significance of a general study prior to initiation of actual design or development effort

Since these quartz crystals are used as frequency standards with an allowable tolerance of plus or minus 0.005 per cent throughout the military temperature range, they clearly must be manufactured within very close frequency limits—approximately plus or minus 0.001 per cent. The operations prior to mounting the blank on its base are all batch-type processes in which the frequency spread of the blanks cannot be controlled to such a close tolerancé. Therefore, it becomes necessary to adjust the frequency of each crystal individual-

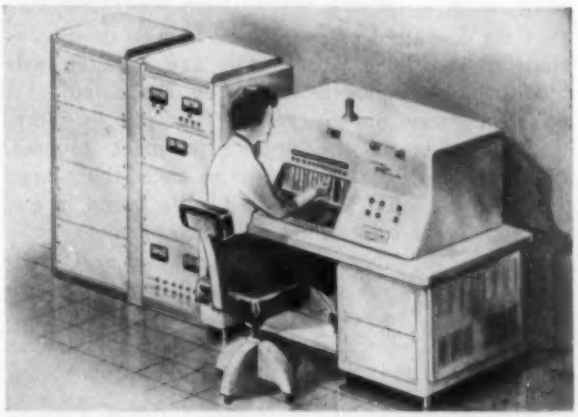


Fig. 5—This prototype x-ray sorter, developed from the experimental model, will automatically sort crystals at the rate of 43 units per minute. The operator will insert cartridges containing unsorted crystal blanks, and remove cartridges of sorted blanks.

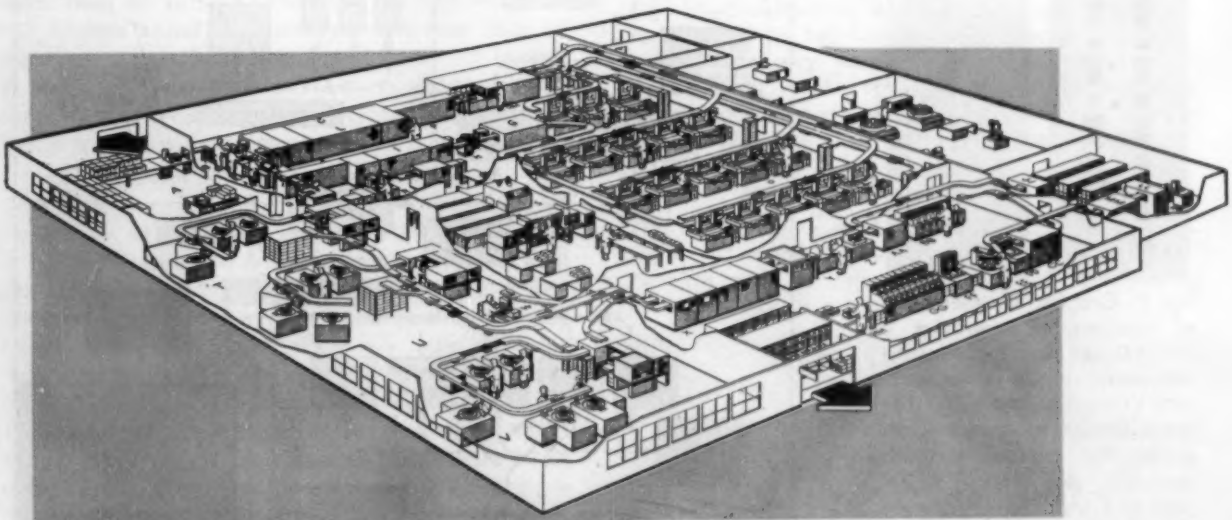


Fig. 6—Original layout of the plant. Designed to produce 200,000 crystals per month on a single shift basis, this plant will require less than 100 employees.

A—INCOMING INSPECTION AND SELECTION OF QUARTZ STONES
B—ROUGH ORIENT STONES
C—WASH, RINSE, ETCH, RINSE, DRY (STONES)
D—MOUNT STONES
E—PRE-POSITION STONES
F—SECTIONING OF STONES
G—DEGREASE
H—DEBURR
I—RINSE, ETCH, RINSE, WASH (SECTIONS)
J—LAYOUT SECTIONS
K—ROUGH ORIENT SECTIONS
L—WASH, RINSE, ETCH, RINSE, DRY (SECTIONS)
M—MOUNT SECTIONS
N—PRE-POSITION SECTIONS
O—WAFERING OF STONES
P—RINSE, ETCH, RINSE, WASH (WAFERS)
Q—LAYOUT WAFERS
R—ULTRASONIC CUTTING
S—X-RAY SORT
T—PRIMARY LAP
U—SECONDARY LAP
V—SEMI-POLISH
W—BEVEL
X—WASH, ETCH, RINSE, RINSE, RINSE (CR-18, CR-23)
Y—BASE PLATE
Z—MOUNT AND CEMENT
AA—CURING OVEN
BB—FINAL PLATING
CC—AGING OVEN
DD—FREQUENCY CHECK
EE—SEALING
FF—FINAL FREQUENCY CHECK
GG—FINAL HEAT RUN
HH—PACKAGING
JJ—BASE—TIN AND WASH
KK—FREQUENCY STAMP CAN
LL—CAN—TIN AND WASH
MM—HYDROGEN ANNEALING OVEN

ly. At the higher end of the frequency spectrum, the adjustment is usually done in two steps. First the mounted blank is electroplated with nickel, and then the final adjustment is made by vacuum deposition of gold or silver while the frequency is monitored.

The most important reason for the intermediate nickel electroplating is that the methods for making the final adjustment have been limited to small adjustments. If larger adjustments were attempted, the amount of metal deposited would cause the crystal to go dead. When we first studied these plating methods, the electroplating was such a combination of making electrical connections, dipping, cleaning, frequency reading, etc., that we despaired of ever being able to mechanize that process successfully. So the decision was made that that process had to be eliminated from the mechanization program. This put an additional burden on the final adjustment process, requiring that plating there be such that large adjustments could be tolerated. We found in our subsequent investigations that this problem was largely one of the accuracy of location and evenness of application of the metal being deposited. We are happy to be able to say now that we have found methods of improving the quality of the metal spot so that we may now make adjustments large enough to overcome all tolerance accumulations without tightening tolerances at prior operations. Thus, the system approach allowed us to find a broad solution to a mechanization problem rather than reducing the program to a series of individual struggles with sometimes intractable processes.

Mindful that a system study such as we had undertaken must lay a concrete foundation for future work, a System Study Report was prepared in which each process was individually discussed, from Item 1—Incoming Inspection of Raw Quartz to Items 29 and 30—Packaging and Final Storage. An outline form was used for clarity and for uniformity. A typical page from the Report is given in *Fig.* 3. Perusal of the sample report page will indicate that the report attempted to establish for each process a definite plan of action and in addition give a best guess as to the final outcome of the engineering effort to follow. As a matter of interest, the breadboard model of the x-ray sorter has since been completely developed, and the prototype unit is now being fabricated. The photograph in *Fig.* 4 is of the breadboard model, and *Fig.* 5 shows a sketch of the prototype X-ray sorter as it will look when completed.* As it turned out, no proportional counter was found with a counting rate high enough for rapid sorting, but

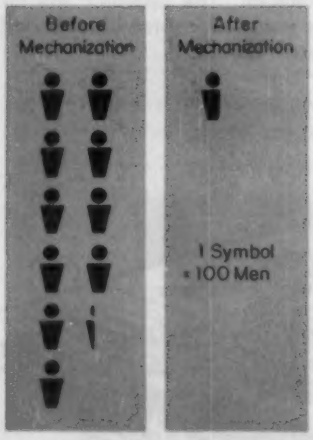


Fig. 7—Graphic representation of numbers of operators a 200,000 per month production rate would require under alternate production methods. The great number of operators required for manual methods would be very difficult to recruit and train rapidly during a military emergency.

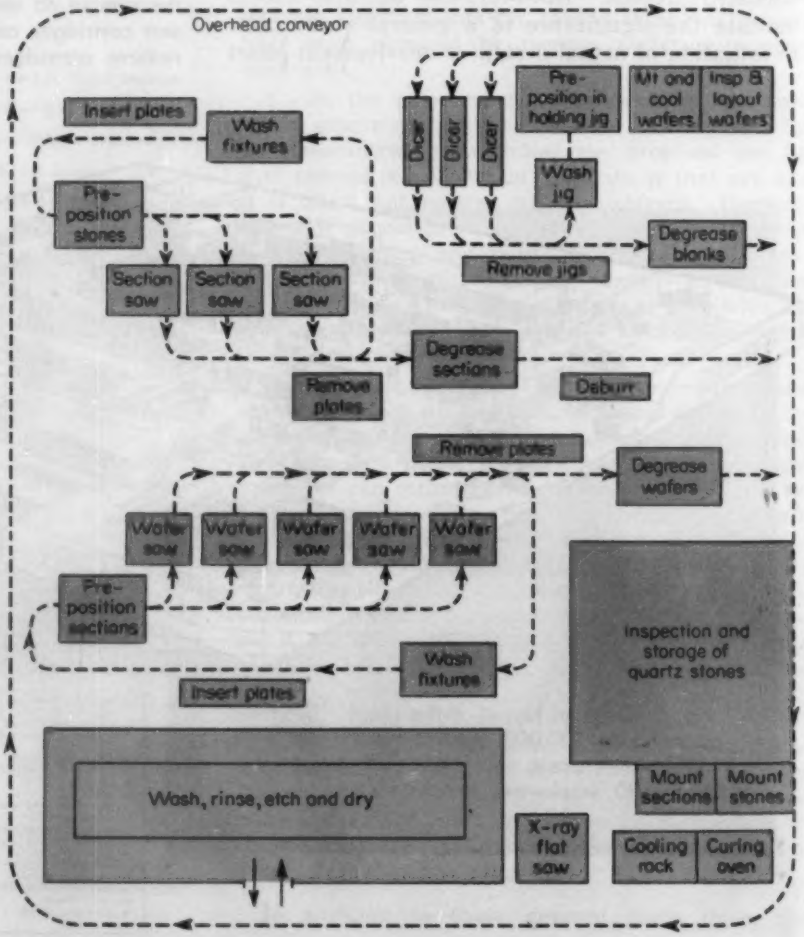


Fig. 8—Revised layout for the cutting area of the plant where approximately 20,000 blanks must be cut per day. This revision covers process steps from *A* through *R* in the original layout, *Fig.* 6.

a scintillation counter developed by the University of Oregon under another Signal Corps contract proved very satisfactory for our purposes. This counter allowed the use of a measurement-while-table-is-in-motion system. Also, the capacity of the machine had to be increased after a more detailed study of plant shrinkage rates. The machine's rated speed is now 43 measurements per minute. Thus, while the report's analysis did not forecast every problem which arose later in the program, the effort of preparing the report forced many problems out into conscious thought, and it has acted as an invaluable guide to the engineers on the program, particularly to those who joined the program after the initial study was completed.

▸ Plant Layout Visualized

Following the establishment of a tentative overall process, estimates were made of the type and quantity of equipment that would be required for the plant. Around these estimates, a plant layout was developed which portrayed as far as possible our visualization of the entire plant, *Fig.* 6. The picture indicates a manufacturing area of about 15,000 square feet containing about 100 pieces of major equipment for some 40 separate process steps. The comparison in *Fig.* 7 emphasizes what mechanization engineers have found before us—that while eliminating the skill from the operator's task, it is often quite easy to eliminate the need for the operator. Whereas previously the manufacturer of 200,000 crystal blanks per month on a single shift might have required 1000 employees, we estimate that the mechanized plant will require about 50 operators and less than 50 other employees including supervisors. It is well to point out here perhaps, that no employees are being displaced by this plant development and some 100 new jobs will be created in its operation.

Detailed inspection of the plant layout will disclose that several stations require duplication of equipment, as it did not seem possible or practical in those instances to design a single machine with the required production. Also, there are a few stations through which the material in process passes more than once. Thus we have departed in several ways from the simple straight-line plant layout. There are at least three reasons for this: (1) To group the equipment for more convenient supervision, (2) to combine identical operations where without combination an operator would have been idle part of each day, (3) because the work in process is so light and easily handled and transported, more complex equipment arrangements could be used.

The plant layout, especially as drawn in perspective, has been a reminder of our final goal when we tended to get involved with the detailed en-

*The prototype x-ray sorter is being fabricated at this writing, and will be completed by March. Bulova Research and Development Laboratories Inc. expects to exhibit it in operation at the IRE Show in March.

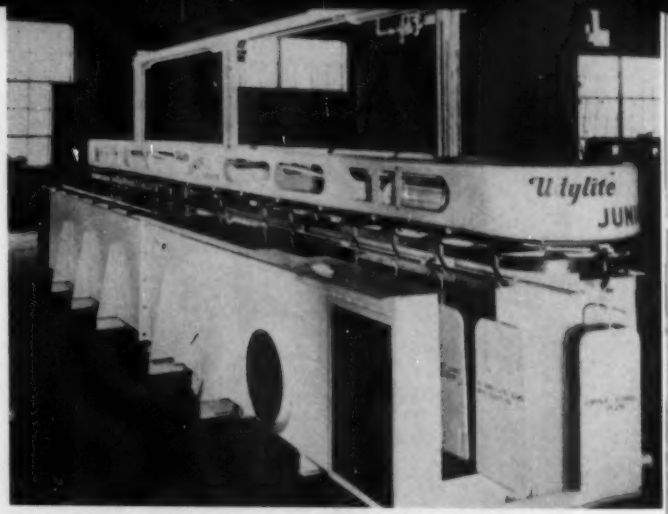


Fig. 9—This type plating machine, specially modified, will be used for cleaning and etching quartz stones, sections and wafers. Quartz material will pass through this machine in four different stages of manufacture.

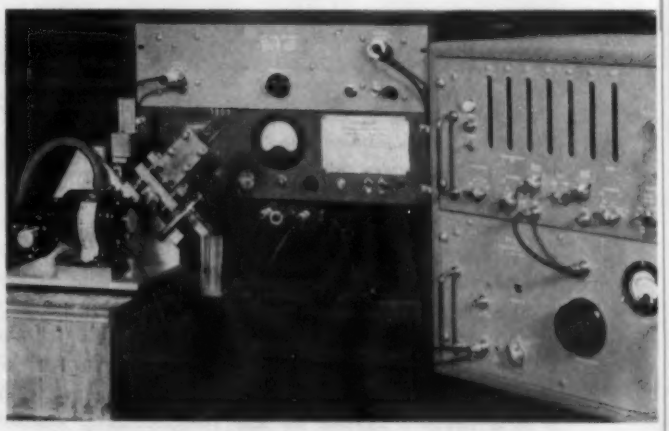
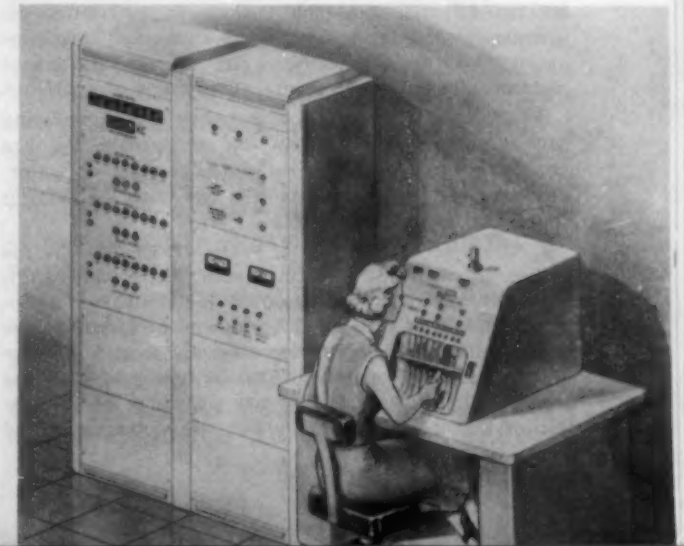


Fig. 10—Experimental model of the frequency sorter. Each crystal is fed between two electrodes and its natural frequency measured. Crystals are classified by a sorting section under control of the frequency measuring equipment. This unit can handle crystals as thin as 0.004 inch at a rate of two crystals per second.

Fig. 11—Frequency sorter prototype, still under development, will automatically sort 50,000 blanks per day. Features such as automatic testing and time-sharing of sorter consoles are planned.



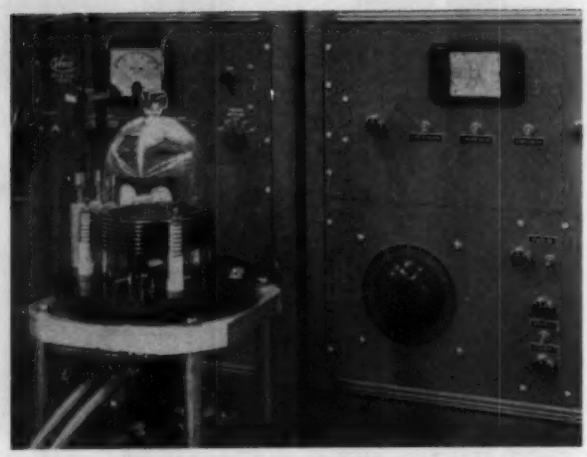


Fig. 12—Base plating of crystals is performed in this evaporation plating device heated by induction. Crystals are held in a mask near the top of the chamber and the aluminum to be evaporated is in a small crucible at the bottom of the chamber.

gineering problems, and it has helped us visualize the relationships of the different machines. But there is a danger, too, in drawing a picture like this early in such a program. It is easy for minds to become frozen into the pattern which the picture represents, and this may stifle original ideas before they are born. Therefore, it is one of the assigned tasks of the systems group to continually revise our conception of the pilot plant in the light of new ideas of those on the program or of others outside our own group. For example, *Fig.* 8 is a revised layout of the roughcutting section of the plant, covering process step *A* through *R*. It is based on what was learned during the first twelve months of the program and contains some significant changes.

1. A Udylite plating machine, *Fig.* 9, has been found to be able, when correctly modified, to handle the etching load of the two machines shown on the original plant layout.

2. As the handling of the material flowing through the etching machine proved to be the most troublesome material handling problem, the entire roughcutting area is surrounded by a single conveyor line for transporting the etch baskets to and from the various process stations. Each equipment group is arranged within the conveyor circle so that its basket pickup and return points are along the conveyor line.

3. The development of a superior quartz-wafering saw by the P. R. Hoffman Co. of Carlisle, Pa. has enabled us to reduce the estimated number of wafering saws required from fifteen to five, thus simplifying the plant layout considerably.

4. The machine groups *A*, *B* and *C*, (in *Fig.* 8) for sectioning, wafering and ultrasonic dicing were originally visualized as composed of individual semiautomatic machines connected by means of transfer jigs which could be easily transported and locked in place by an unskilled operator. Further analysis of these processes indicates that they are suited to the application of transfer machinery which would transport and lock the jigs in position in a completely automatic cycle, with operators required at some stations for certain manual operations. Those three machine groups as revised are shown in the revised layout, *Fig.* 8.

5. Conversely, at the mounting stations for the stones and sections it was originally felt that conveyor ovens and dryers would be best. However, later study has shown that it will be more economical to handle these operations on a batch schedule, so rack-type ovens will be used in which the racks will be manually wheeled in and out of the ovens on a time schedule. Which tends to prove that one can over-automate as well as under-automate, and it is very difficult to draw the line. It is this writer's opinion that for many years to come the decision concerning the degree of automation will be in engineering's lap, rather than at top management or in a computing machine, and it will be ability and experience as always that will be the basis of the decision rather than any formula.

The Operations Research Tool

By a continual process of analysis and experimentation, the machine developments are bound into an integrated plant unit with a balanced production capacity, guaranteed product quality, and the greatest possible reliability and ease of supervision. One of the analytical tools which has been of great value in our search for the optimum plant design is the technique called operations research. Operations research is a mathematical approach to industrial engineering and its particular strength is in finding the optimum solution to a problem with many variables. We have used mini-

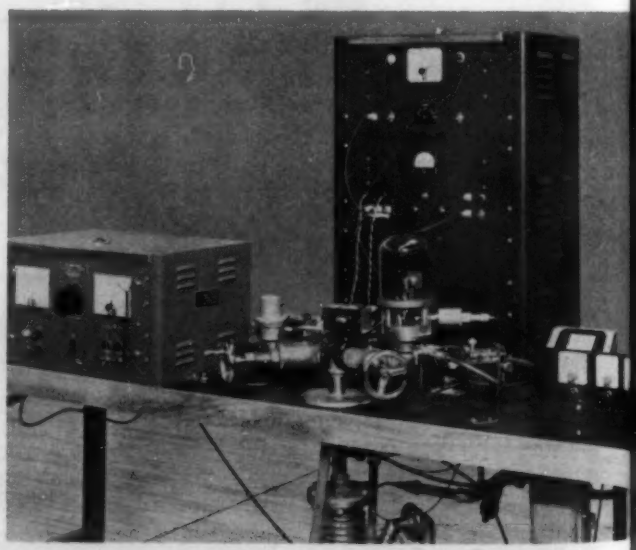


Fig. 13—Final adjustment of crystal frequency is by sputtering of gold in this experimental model with an automatic plating cycle. Under a vacuum, high voltage between gold electrodes and the base of the chamber causes gold particles to be emitted from the electrodes. Some of these particles adhere to the crystal and change its natural frequency.

mum cost as our criterion in most of our analyses to date and have included such factors as cost of development and fabrication, and operation costs such as direct and indirect labor and maintenance.

Progress Toward Solution

Having outlined methods being used to develop the mechanized plant for quartz crystal manufacture, it may be well to summarize briefly the progress which has been made since the program was formally initiated in September 1954. Engineering effort has been expended in developing the following items:

Initial Etching Equipment: The cleaning and etching process has been established experimentally, and a Udylite Junior plating machine has been found suitable for this purpose with the proper modifications for the desired process, *Fig.* 9. The machine has been integrated into the plant layout as described previously.

X-Ray Sorter: The experimental model of this machine, *Fig.* 4, has been completely developed and its accuracy has been determined. Its precision of measurement is better than 10 seconds of arc, one standard deviation. In less technical terms, the machine will sort 95 per cent of all crystals into the correct bin, the other five per cent being the borderline cases that will fall into one of the two adjacent bins. This accuracy was formerly obtained only in laboratories, and the machine incorporates a method of measurement which was formerly only a laboratory technique. Operator skill in sorting has been completely eliminated, as the operator merely inserts and removes crystal holders which receive the output of the x-ray sorter. These crystal holders are cartridges similar in operation to a train conductor's change dispenser. The cartridges are designed to be used as crystal collectors, dispensers, and storage devices. The output of the thickness sorter which precedes the x-ray sorter will feed directly into the x-ray sorter. Thus the consecutive machines are integrated in design, and intermediate handling stages are eliminated.

The x-ray sorter's rated speed is 43 crystals per minute, or 18,500 measurements per day, including 10 per cent down time. This compares with 1500 to 2000 crystals per day for a skilled operator sorting manually.

Frequency Sorter: This machine is required for checking the frequency of the blanks during the lapping process. Because each blank must be measured several times, the capacity of this machine will be two blanks per second, or about 50,000 measurements per day, allowing for downtime. This again compares with about 1500 per day for a skilled operator. The sorting of measured blanks is completely automatic.

Development of an experimental frequency sorter, *Fig.* 10, is almost complete, and the final design is in process. A sketch of the final prototype is shown in *Fig.* 11. It is similar in external design to the x-ray sorter, but it operates on entirely different principles.

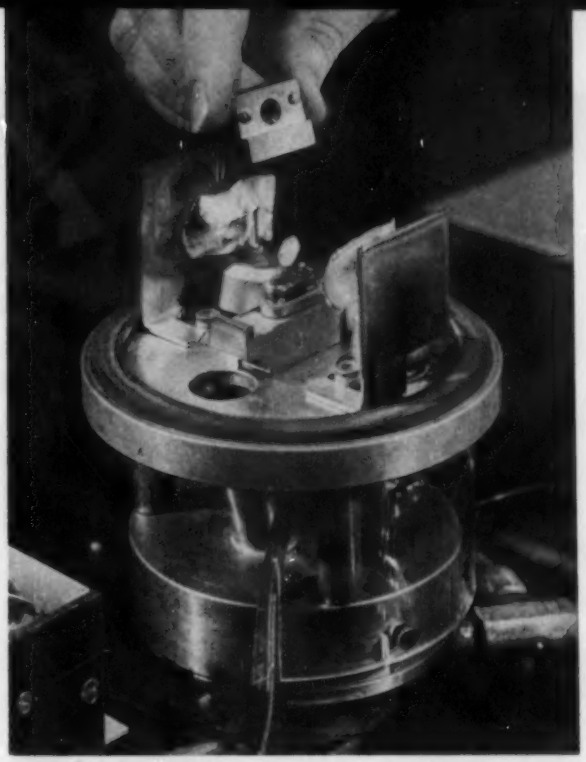


Fig. 14—Close-up of the sputtering chamber shows the mounted crystal in position for plating, the electrodes, and the mask which fits around the crystal unit. Development of the mask technique eliminated a preliminary plating operation.

Electronic counting equipment for the frequency sorter has been subcontracted to the Berkeley Division of Beckman Instruments and is designed to time-share several sorter consoles either in automatic sequence or at operator command. The unit also incorporates an automatic test cycle which tests the electronic section completely. The testing circuit, however, contains no electronic components, and thus does not add complexity to the basic unit.

Final Etching Equipment: An etching and cleaning process is required to improve the surface quality of the blanks before base plating. It is a very critical process, and therefore considerable time is being used to establish a firm process before machine design is initiated. Ultrasonic cleaning and ultrasonic etching with hydrofluoric acid are being investigated. A conveyor type of machine similar to the Udylite machine but considerably smaller is visualized for this process. It will have an automatically timed cycle, and the temperatures and concentrations of the various solutions will be carefully controlled.

Base Plating Equipment: In the final steps of the preparation of the crystal, it is necessary to plate each side of the blank to make electrical contact with the active vibrating portions in the center of the blank, *Fig.* 12. This is commonly done by evaporation plating techniques, with silver

being a typical metal used. Evaporation plating is a batch-type process plating about 30 blanks at a time. After this operation, the blank is mounted in springs which are attached to the base. The springs act both as supports and electrical connections to the plated electrodes. Besides mechanizing this plating process to eliminate decision-making by the operator, we have attempted to find production means for evaporating aluminum rather than silver or gold. Use of aluminum as the base plate material increases the quality of the crystal and extends considerably upward the useful frequency range of the equipment. Substantial inroads have been made on this problem by the use of spherically-shaped tantalum crucibles for long crucible life. Induction heating is now being investigated, as this allows the use of non-metallic crucibles and possible further increase in crucible life. Early results indicate a good chance of success for induction heating. If this proves to be true, the development of the base-plating equipment will have been brought to a very satisfactory conclusion.

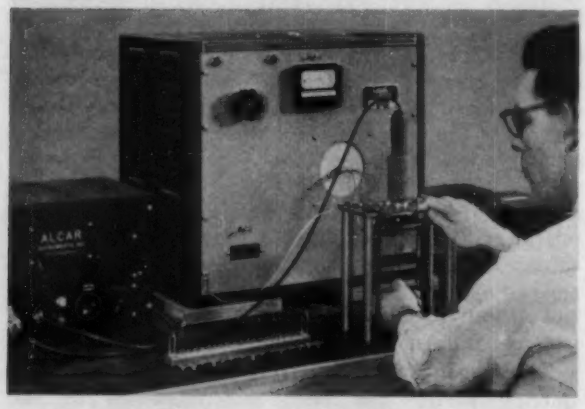


Fig. 15—Crystal units are completed by soldering a can over the mounted crystal. This sealing unit automatically carries out the soldering cycle after it is initiated by the operator. The method used applies induction heating and ultrasonic agitation.

Final Frequency Adjustment: After the crystal is mounted in its spring holders, a final adjustment of its frequency is made by additional plating while the crystal frequency is being measured. We have been using sputtering of gold, a high voltage vacuum technique. A breadboard unit, *Fig.* 13, has been completed which satisfies the basic requirements of the program. It incorporates a completely automatic evacuating and plating cycle, including automatic tapering of plating rate as the frequency approaches shut-off, and automatic shut-off when zero frequency error is reached. The operator merely loads and unloads the crystal unit in the chamber, and starts the cycle.

The small mask shown in *Fig.* 14 is used to cover the crystal unit during plating and allow only an accurate spot of gold to be deposited on the crystal. As mentioned previously, the development of this mask has made possible extremely large adjustments at this stage with corresponding advantages.

Because the sputtering process is a comparatively slow one, we are investigating the use of evaporation plating, incorporating the control equipment and the mask discussed. There are several difficulties involved in evaporation plating which do not occur in sputtering, but if these problems can be solved, a substantial saving in equipment first cost should result due to the faster plating cycle.

Sealing Equipment: The cans and bases are commonly sealed with soft solder. Aside from the elimination of operator skill, two problems were apparent. The standard hot plate soldering method using flux often did not produce the hermetic seal required to prevent frequency shifts of the crystal unit after shipment. Also, the flux itself acts as a contaminant and often causes frequency shifts. Several paths other than soldering looked attractive, such as sealing in glass and several welding techniques. However, none of these processes were advanced enough in development to be mechanized, and development of any of these processes was deemed beyond the scope of the program. An approach to soldering by the use of induction heating and ultrasonic agitation held out the possibility of getting good seals without flux, and was eminently suited to mechanization. An experimental model has been developed using this method, *Fig.* 15, with a sealing cycle not dependent on the operator. The results have been quite satisfactory. About 90 per cent of the units have shown no perceptible leak when tested with a mass spectrometer, the most sensitive leak detector known. All of the units pass the less sensitive standard Signal Corps leak test. The design of the final sealing equipment is now under way, following the basic design of the experimental model.

In addition to the development work outlined above, much system work has been accomplished in establishing specifications for the manufacturing processes, and in investigating certain of the processes such as sawing, lapping and ultrasonic dicing prior to initiation of machine development effort.

The present schedule calls for all prototype equipment to be completed by February 1958. It is estimated that the additional time required to set up the entire plant and put it in standby operation is one year.

The Bulova organization has welcomed the opportunity to develop this mechanized plant for manufacture of quartz crystals, and successful results will show that mechanization can be applied to the mass production of small, high precision components through planning and development by a combination of systems engineering and know-how in the development of mass production machinery for precision parts.

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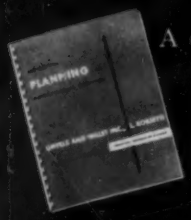

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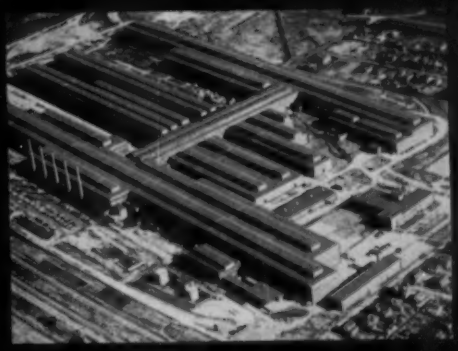

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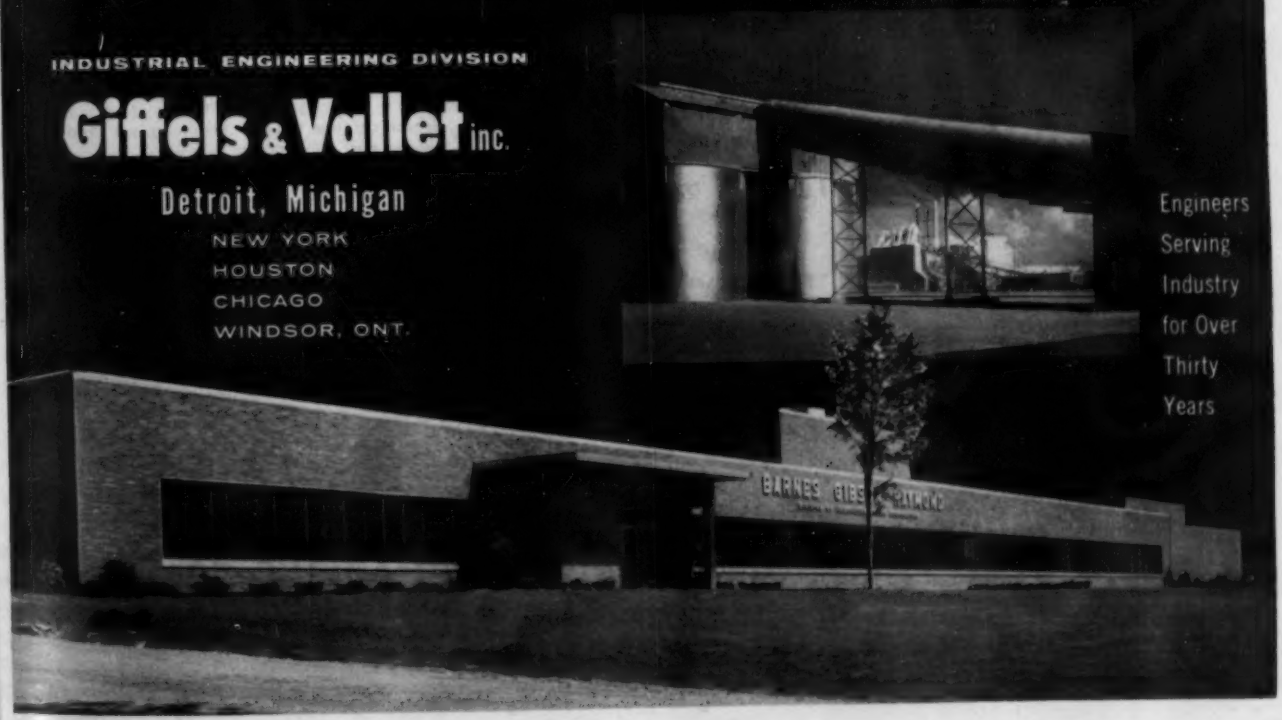

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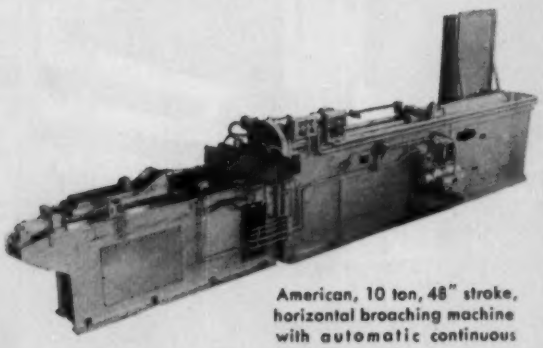

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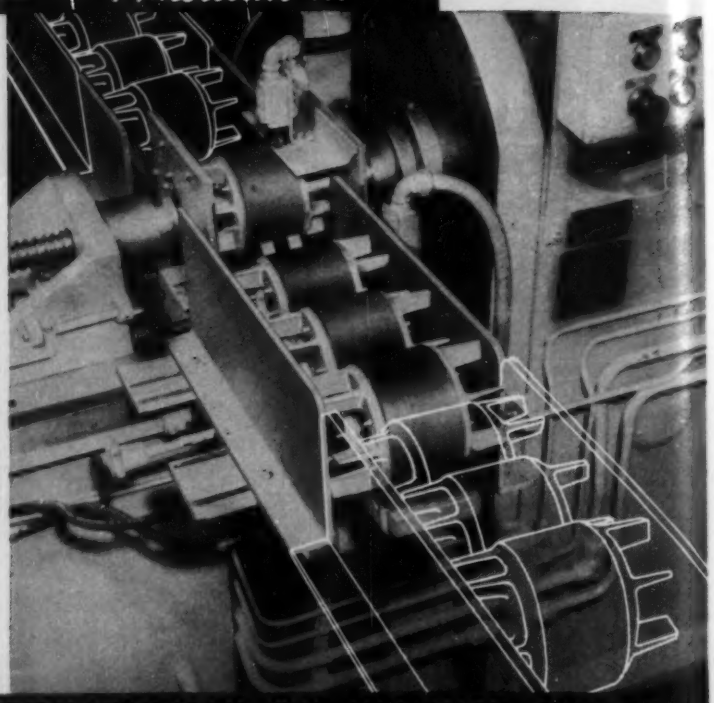
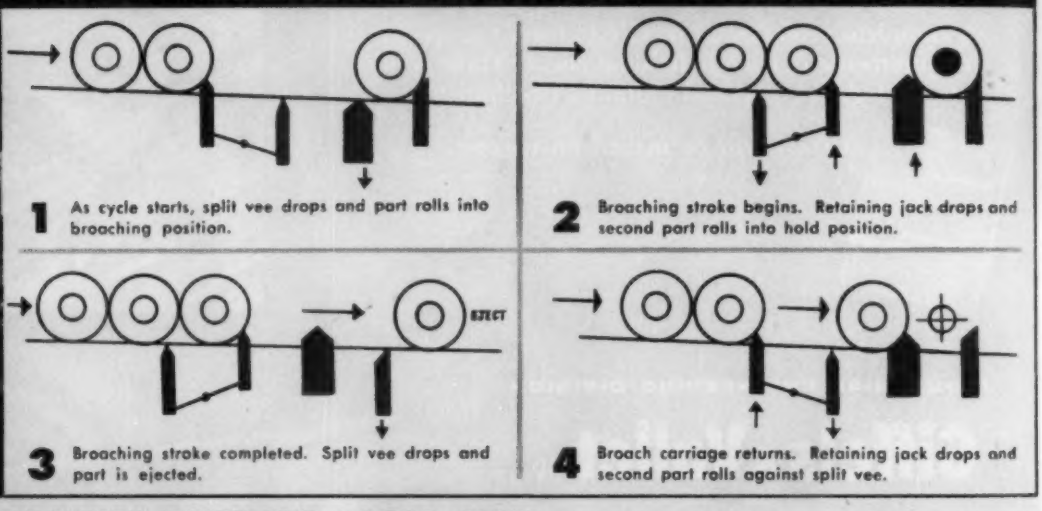


PARTS FED AND EJECTED AUTOMATICALLY ON INCLINED CHUTE



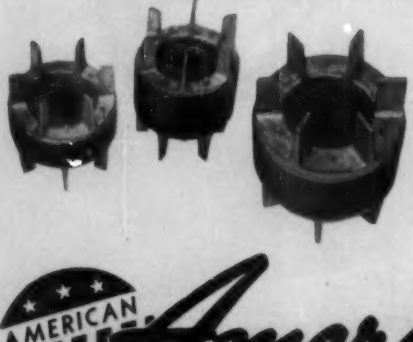
1 As cycle starts, split vee drops and part rolls into broaching position.

2 Broaching stroke begins. Retaining jack drops and second part rolls into hold position.

3 Broaching stroke completed. Split vee drops and part is ejected.

4 Broach carriage returns. Retaining jack drops and second part rolls against split vee.

MACHINE BROACHES DIFFERENT ROTOR SIZES



Thrust bushings on the clamping mechanisms seat in the I.D. of the rotors' fan sections. Simply by changing these bushings and adjusting the chute guides horizontally and/or vertically, rotors of varying diameters and thicknesses are broached on the same machine.

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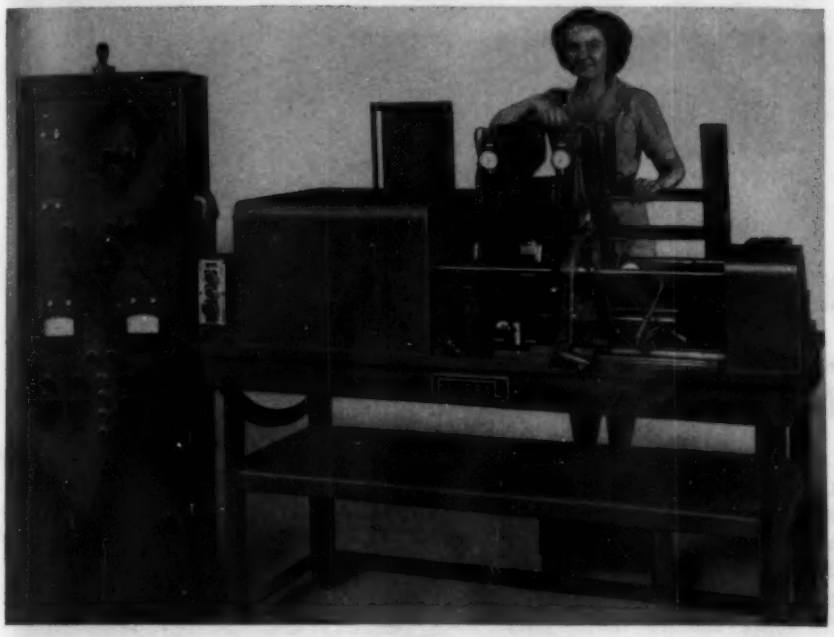
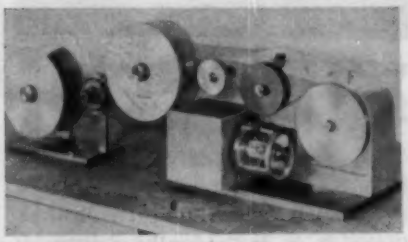


No. 1—

Conveyor Fed Sorting Gage

In-process dimensional control is provided by automatic sorting gage which fits into production lines. In one application, gage is an integral part of the production line of an automotive equipment manufacturer. Conveyor-fed model measures six conditions on automobile push rods. Gaging units and reluctance hardness testers check push rods for outside diameter and hardness at both ends, overall length and straightness. Parts are sorted into three categories—good, salvage, and scrap—automatically at a rate of 2500 per hour. Good parts are fed to a conveyor to continue to the next process, while scrap and salvage parts are sorted into separate bins out of the production line. To give maximum control over various processes, percentage counters are provided at each gaging station. When number of rejects at any station exceeds allowable limit, gage flashes signal lights and operates relays to shut off offending process machine. System actually controls amount of scrap in this manner. **Federal Products Corp.**, 1144 Eddy St., Providence 1, R. I.

Circle No. 1 *on Reply Card*



No. 2—

Resistance Winder

Resistance wires are automatically wound on continuous lengths of core material from 300-ft or larger capacity spools, to be cut and made into flexible wire wound resistors, heating elements and coils for other applications. Resistors are used in printed circuit and other automatic or manual assembly operations; heating elements are used in electric blankets, heating pads, high altitude flying suits and other thermal applications. Winding speed of unit is up to 6000 rpm with variable speed series motor for wire sizes ranging from 0.003 to 0.012-inch. Up to 850 rpm winding speed is attained with variable speed shunt wound dc motor with self-contained dc source for wire sizes ranging from 0.003 to 0.0012-inch. Tension is controlled by special adjustable spring device which is part of the machine. Maximum outside diameter of material upon which wire is wound is ¼-inch. Coils can be as long as desired. Take-up spool is capable of holding more than 300 ft of finished wound ⅛-inch diameter material. Two take-up spools are supplied. Level wind device prevents tangling during drawing on the take-up spool. **Geo. Stevens Mfg. Co. Inc.**, Pulaski Rd. at Peterson, Chicago 30, Ill.

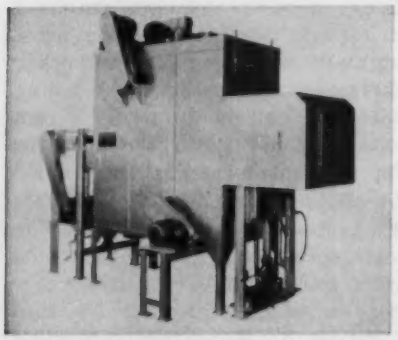
Circle No. 2 *on Reply Card*

No. 3—

Painting System

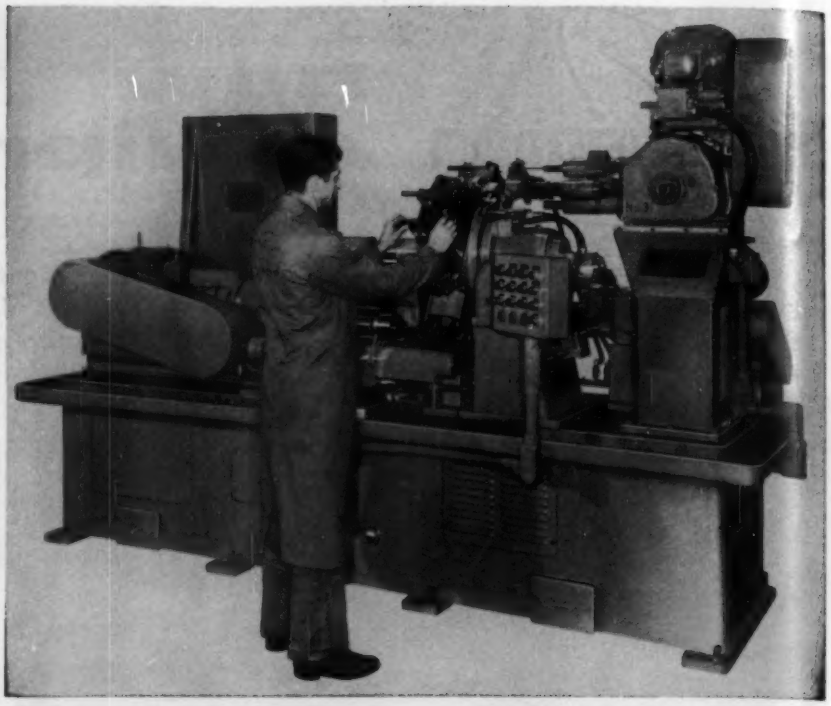
Applying a ground paint coat on the handles of cutlery pieces, baking and preheating, applying a finish coat, baking again and delivering at the rate of 24 pieces per minute ready for assembly is accomplished with packaged coating and baking unit. Oven has a horizontal conveyor and two movable dip tanks. Cutlery pieces are suspended vertically from parallel bars attached to two strands of roller chain which convey the

bars through the various stations. Cycle is as follows: After work is mounted on the bars, conveyor moves forward in its underpass to a point where the ground coat tank is raised to permit dipping of the pieces on one bar. Simultaneously the tank at the other end of the oven is raised to dip a bar of work with the finish coat. Timer indexes the conveyor so that the work is immersed in each tank for the same time. Then each tank is lowered and the conveyor moves to bring each succeeding bar into position over the tank and the process is repeated. In between the two dip tanks the pieces move through the oven for baking the



ground coat and preheating for the finish coat. From the finish dip coat tank the conveyor carries the work over sprockets in the return overpass of the conveyor through the second bake to the original point for removal of the pieces from the bar. Heat is supplied by two banks of electric heaters, one mounted under the conveyor and one above it, with motor driven multiblade fans supplying the recirculating air. Motor driven exhauster on the roof removes the volatiles. Conveyor is powered by a constant speed motor drive with brake and starter. Movement of the coating tanks is effected by air cylinders. Conveyor does not move until both tanks are in the lowered position and actuate limit switches. Cylinder heads are equipped with screw type arrangements to vary the tank height for various size pieces. Each tank has a motor driven recirculating pump. Oven is made of aluminized steel panels insulated with glass wool preformed blocks. **W. S. Rockwell Co.**, 200 Eliot St., Fairfield, Conn.

Circle No. 3 on Reply Card



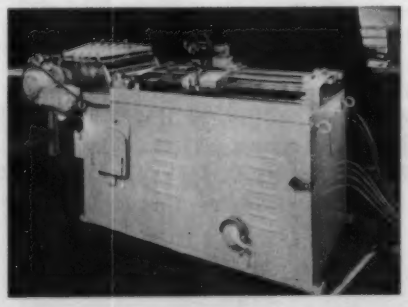
No. 4—

Milling and Threading Machine

Indexing type hollow milling and threading machine employs two lead screw tapping units and one cam feed drill unit in a four-station operation on forged steel tie rod sockets. A dual loading air clamping fixture holds parts for work cycle.

New machine performs the following operations: hollow milling and threading stems, drilling and tapping for zerk fittings. Miller and threader completes 430 parts per hour at 100 per cent efficiency. **Hartford Special Machinery Co.**, 287 Homestead Ave., Hartford, Conn.

Circle No. 4 on Reply Card



No. 5—

Slide Feed

Independently driven slide feed is designed for feeding coil stock into punch presses or press brakes. Since it is individually driven, it can be used for feeding in any direction, right to left, left to right, front to back or back to front. Illustrated model is equipped with a slide feed. Width capacity is up to 24 inches; maximum feed length is adjustable up to 24 inches at one stroke. Feed is powered by a 5 hp motor with variable speed control. An electrically controlled, air operated gripper is mounted in the feed block; electrically controlled air operated check is arranged so that pilots can be used. Inching control is provided on the feed for inching material into disks; inching button for the press is also furnished. Unit has an automatic arrangement for single stroke operation with press running continuously. Counter for cycle feeding can be preset to allow feed to make a predetermined number of strokes up to 400 before press is tripped. After making the predetermined number of strokes, feed stops, trips press and counter resets itself. **U. S. Tool Co. Inc.**, Ampere, E. Orange, N. J.

Circle No. 5 on Reply Card

IT WILL SAVE YOU TIME AND MONEY TO ADD "CROSSBAR" TO YOUR AUTOMATION VOCABULARY

Here is why Crossbar takes the place of Relay Tree in your automation vocabulary: With the Kellogg Crossbar several switching operations can be carried on independently at the same time . . . entire switch can be mounted in drawer-type frame for easy inspection . . . contact material is palladium (or gold) . . . any crosspoint can be activated in less than 50 milliseconds.

ECONOMY

Kellogg Crossbar:

- Requires practically no routine maintenance
- Is equivalent to a bank of relays, assembled, mounted, and partially prewired
- Uses less hardware
- Uses fewer coils
- Consumes less power

ADAPTABILITY

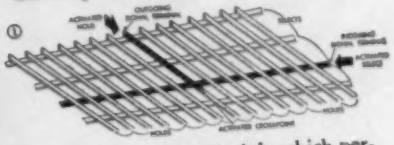
Kellogg Crossbar has been adapted to a wide variety of industrial applications.

ENGINEERING HELPS

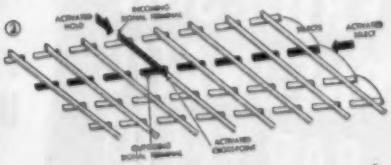
Kellogg engineers will show you how Crossbar advantages will work for you. Saves design time.

crossbar (krôs'bär')

The most modern, compact, fast, and economical means of concentrating hundreds of relay or switching operations for practically any automatic control, computing, reporting or sequential sampling operation.



The basic Crossbar principle which permits any of several incoming circuits to be connected to any of several output circuits is illustrated above. This switch actually can connect any of 60 circuits, 3 at a time, to any of 75.



The drawing above shows a means of switching one incoming circuit to many possible outgoing circuits. This type of switch can easily be adapted to switch one circuit to as many as 936 circuits.

cross-bill (krôs'bil'), *n.* any of several species of finch having curved mandibles whose points cross each other.

KELLOGG
A DIVISION OF
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A Division of International Telephone and Telegraph Corporation
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☐ Please send me the booklet on Kellogg Crossbar

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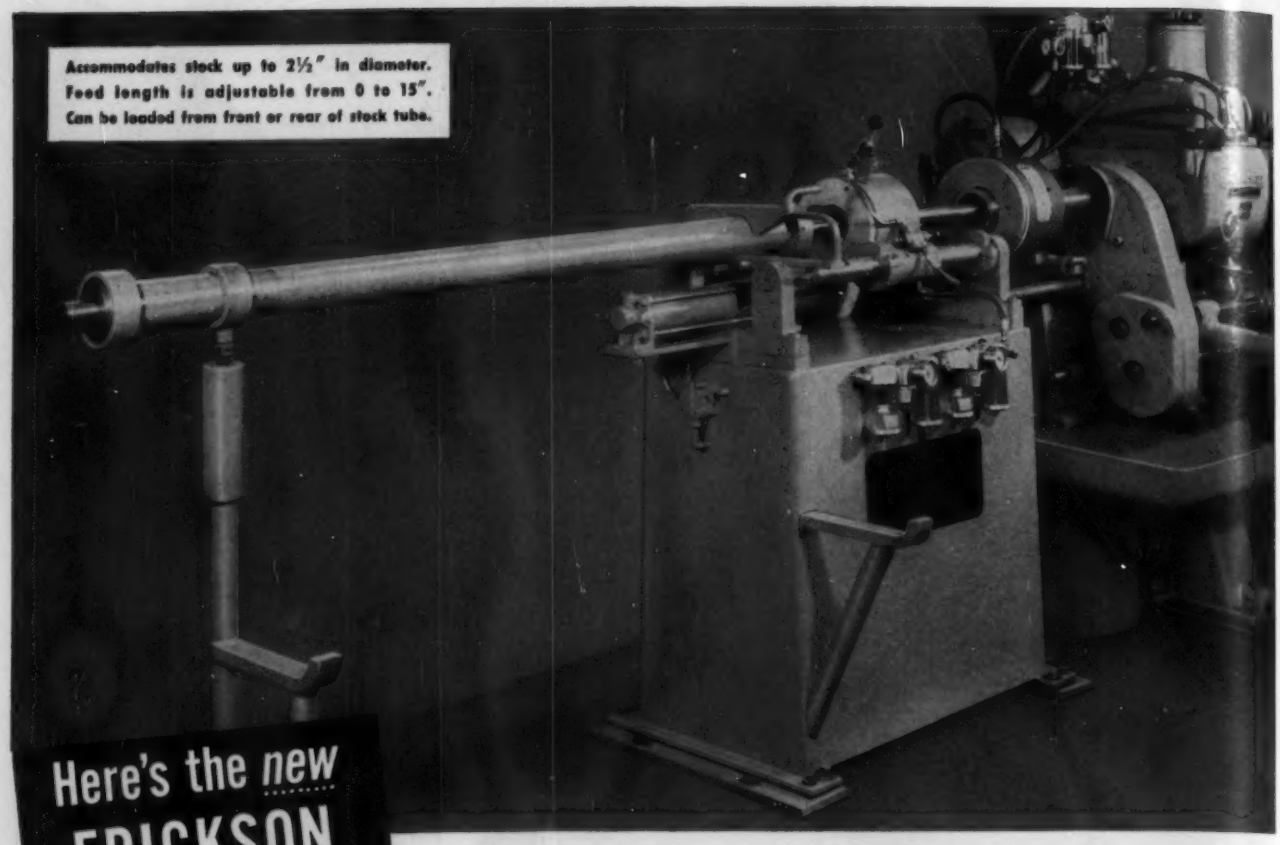
CROSSBAR BOOKLET


Accommodates stock up to 2½" in diameter.
Feed length is adjustable from 0 to 15".
Can be loaded from front or rear of stock tube.

Here's the *new* ERICKSON PNEUMATIC BAR FEED!

...An Automatic Air Stock Feed and Collet Operating Unit Designed to Operate with any Collet Equipment

• *Increases production* • *Reduces operator fatigue*

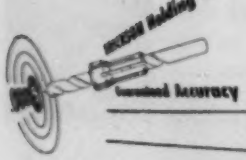
THIS NEW ERICKSON Stock Feed automatically feeds bar, hex or tubing stock to your machine tools for rotating or non-rotating machining operations. It is an air-powered, fully automatic unit which is quiet, simple to operate, safe to use, rugged and dependable. It can be used with any type of collet equipment.

EASE OF OPERATION reduces operator fatigue and speeds set-up cycle time. One valve controls entire operation. At a flick of the valve handle, spindle collet opens and feed chuck advances stock to preset length; feed chuck then opens its jaws. Another flick closes spindle collet on stock and returns feed chuck to its starting position where it closes its jaws on stock to give double grip.

AA-976

OPERATIONAL ADVANTAGES

- Assures positive movement of stock. No dragback of stock on return stroke.
- Adjustable feed chuck jaw pressure eliminates marring or crushing of stock while providing positive grip.
- Permits use of exact size, polished stock.
- Provides double grip on stock to resist "pushback".
- Stock feed is adjustable to suit cycle time and bar size.
- Stock moves with spindle rotating to reduce cycle time.
- No safety controls needed due to basic design.
- Filler tube is supported over its length by ball bearings in stock tube. It rotates with stock to prevent marring, eliminate chatter.
- Rugged welded base construction rigidly supports feed chuck, dampens vibration, reduces whip, guaranteeing smoother finishes, quiet operation.



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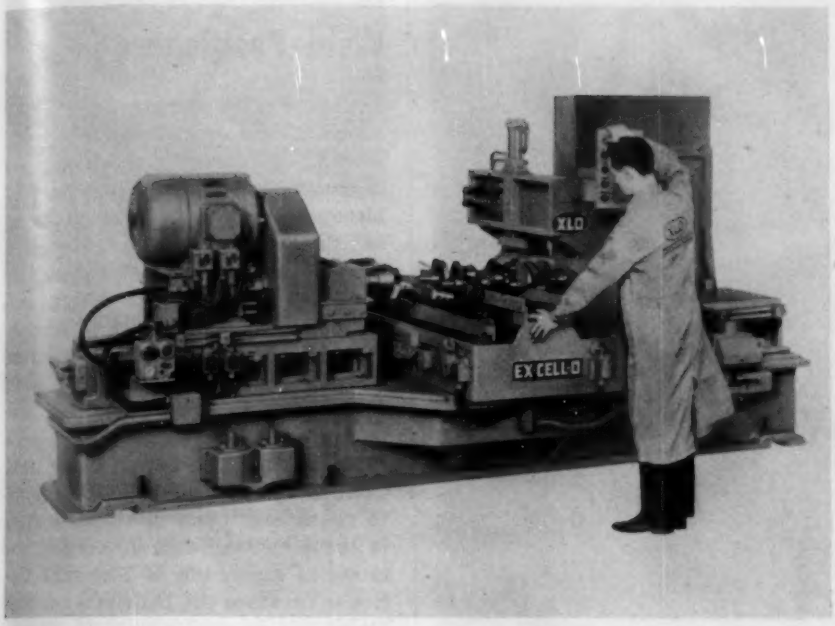
ASTE Show, Chicago
March 19-23

For complete information on the new Erickson Pneumatic Bar Feed, send for your copy of Circular K-2 today!

ERICKSON TOOL COMPANY

2307-3 Hamilton Avenue • Cleveland 14, Ohio

COLLET CHUCKS • FLOATING HOLDERS • TAP CHUCKS • TAP HOLDERS • AIR-OPERATED CHUCKS
EXPANDING MANDRELS • SPECIAL HOLDING FIXTURES

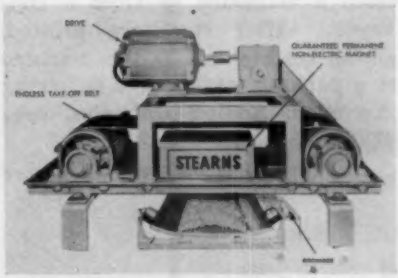


No. 6—

Crankshaft Facing and Boring Machine

New machine enables application of automation in departments remote from a main automation line. As a feeder of finished or semifinished parts to the main line, it is often adaptable to such space as is available, making unnecessary the need for changes in the existing plant floor layout. In one application, through performing triple operations simultaneously on two crankshafts, machine reduces production costs of an automotive manufacturer. Loaded and unloaded automatically, machine is arranged to receive and discharge workpieces by conveyors, resulting in less handling and accelerated output. Operations on crankshafts included finish boring a diameter within limits of ±0.0005-inch, and holding the bore concentric with the main bearings; facing a surface square with the main bearings; and chamfering an edge. Machine uses two hydraulic slides mounted on a base with a fixture between them. At the beginning of each successive machine cycle, two crankshafts have been completed in the machining station while a second pair is in ready position. In motion, transfer bars move the finished crankshafts to an unloading device, while the others are brought into machining position. Hydraulic chucks grip the latter two crankshafts and rotation begins. Nonrotating tools advance horizontally to finish bore the crankshaft ends. Facing and chamfering tools descend from above to engage workpieces and complete machining cycle. **Ex-Cell-O Corp.**, 1200 Oakman Blvd., Detroit 32, Mich.

Circle No. **6** *on Reply Card*

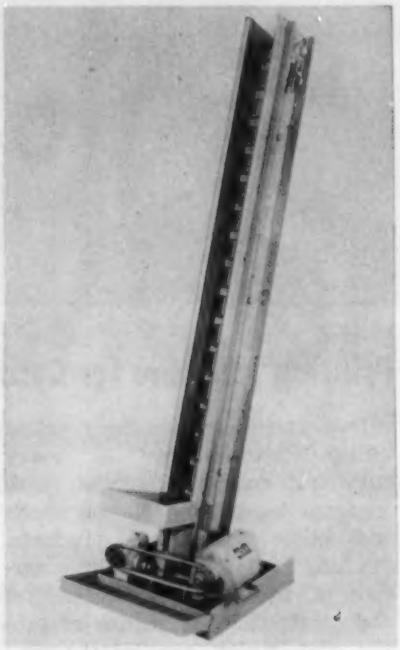


No. 7—

Magnetic Separator

Tramp iron is removed and automatically discharged away from the flow of material in a continuous operation by new cross belt magnetic separator. Suspended above a conveyor belt, chute, or sorting table, permanent magnetic components of unit create a deep magnetic field that pulls dangerous tramp iron out of the material flow. Contaminating iron is attracted to the magnet face where a cleated endless belt automatically carries it out of the magnetic field to discharge harmlessly away from the conveyor or chute. Frequent magnet inspection and hand cleaning are eliminated. Unit is supplied completely assembled including integrally mounted motor reducer drive. No electric power is required other than that necessary to drive the fractional horsepower motor. Separator is available in various sizes, suitable for suspension up to 4 inches above the material flow. **Stearns Magnetic Inc.**, Milwaukee 46, Wis.

Circle No. **7** *on Reply Card*

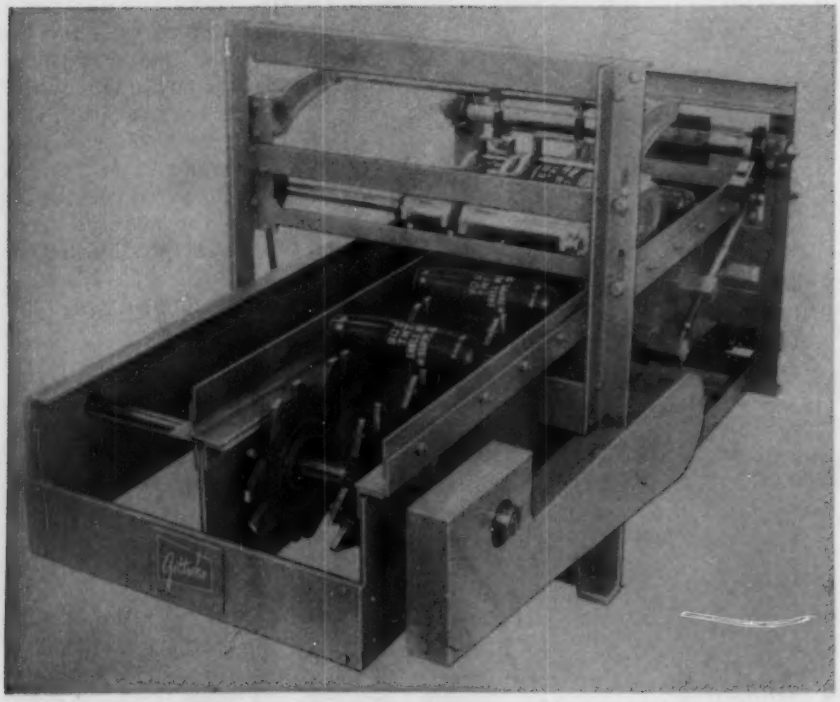


No. 8—

Small Parts Conveyor

Designed to convey small parts from screw machines, centerless grinders, automatic cut-off machines and similar equipment, new conveyor loads from its own hopper directly into a box type trap. Snug fitting steel drag plates, rivet mounted on the conveyor's double roller chain belt, keep the trap continuously closed at the bottom to prevent spilling, overflow and clogging. Called the Trap-Veyor, new unit can be discharged into tote boxes and bins, or directly onto a main line belt conveyor from a battery of machines. Illustrated model, which is designed to handle parts such as large nuts, is powered by ¼ hp, 220 or 440 v, 60 cycle, three-phase totally enclosed motor with right angle reducer for approximately 50 fpm operation. **Metzgar Conveyor Co.**, 408 Douglas St., N.W., Grand Rapids 4, Mich.

Circle No. **8** *on Reply Card*



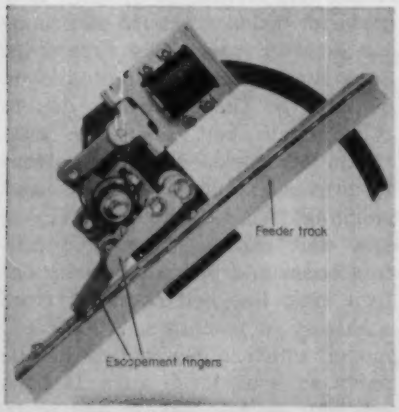
No. 9—

Printing Machine for Cylindrical Products

New printing machine, called "Auto-Cylindaprinter," is heavy duty unit designed to print three separate legends on 90-mm shells and other cylindrical products. Printing is done on the ogive surface at the head, at the center and at the base by means of rubber dies which are interchangeable. Opaque permanent yellow or other standard color inks are used which dry within seconds after printing.

Metered inking rollers incorporated in the machine are said to assure uniform impressions. Shells may be fed to machine by hand, from a magazine or from a conveyor. After they are printed, shells are ejected by the machine to a packing station or a following conveyor. **Adolph Gottscho, Inc.,** Hillside 5, N. J.

Circle No. 9 on Reply Card



No. 10—

Parts Escapement Unit

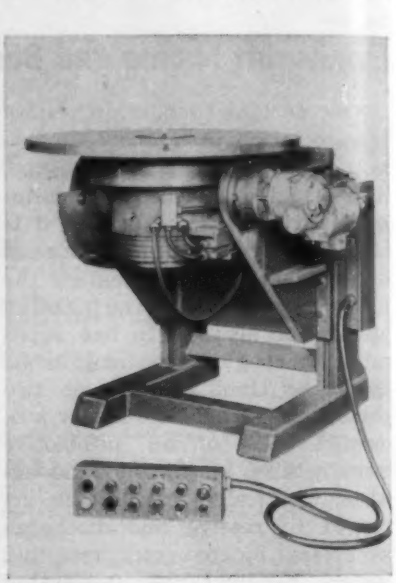
Designed for use when installing automatic equipment or converting existing equipment to automatic parts feeding, standardized parts escapement unit can be attached to any point along a feed track. Spring loaded fingers automatically release individual parts. Escapement will not jam or damage piece parts. No special slots or track junctions are required. Parts escapement unit will automatically release up to 200 parts per minute, one at a time. Escapement fingers can be shaped to accommodate any piece part up to 3 inches in diameter. Units are available for solenoid or air cylinder operation. If a convenient vertical movement is available, mechanical linkage may be used. **Dixon Automatic Tool Inc.,** 2304 23rd Ave., Rockford, Ill.

Circle No. 10 on Reply Card

No. 11—

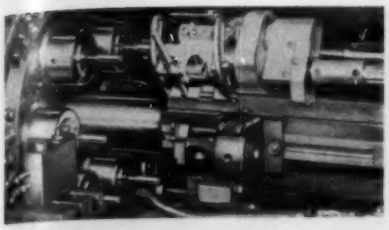
Weld Positioners

Used in the automatic welding of cylindrical or circular piecepart, welding positioner provides mechanical support, and rotation of piecepart about its axis in front of the welding head. Rotation drive, therefore, provides speed of travel of the arc, and design and performance reflect the precision, stepless adjustability and speed of response. Welding positioner with feedback control has 2500-lb capacity and is capable of 360-degree rotation and 135-degree table tilt. Control is designed to permit table to reach maximum speed of 2 rpm in three cycles, when speed control is set at maximum of 2 rpm. Positioner rotation tilt is driven by 440



v, three-phase, 60 cycle motor with limit switches and mechanical stop to prevent overriding. Tilt motor has forward and reverse motion with inching and jogging action in either direction. Feedback control maintains precision of ±20 rpm. Limit switch is used for automatic stepping of positioner at end of circumferential weld. Switch is actuated by adjustable trip located to permit one complete revolution in either direction. Trip is installed to permit zero to one revolution on variable adjustment, at a 40-inch diameter. Actuation of the switch sets regulator to zero speed signal, thus stopping motor in three cycles or less. **Sciaky Bros. Inc.,** Dept. M-4, 4915 W. 67th St., Chicago, Ill.

Circle No. 11 on Reply Card

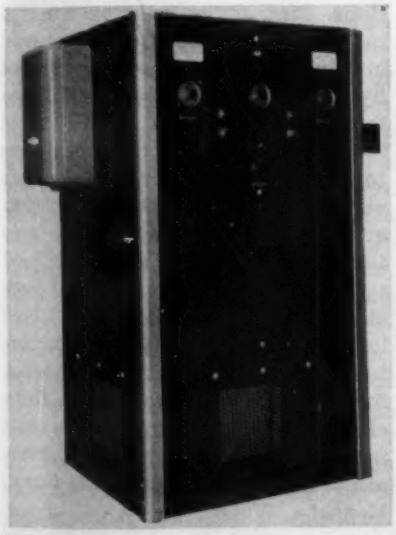


No. 12—

Milling Attachment

Designed for use with multiple spindle automatic screw machines, new attachment permits milling any number of flats or slots while part is turning in the spindle. It operates during the normal cycle of screw machine and advances with end tool slide, or can be accelerated. Device mills slots, forms hexagons or any number of flat sides. Number of flats or slots milled is determined by the cutter design. Models are available for every size and type of multiple spindle automatic screw machine, and are adjustable to full capacity of any of these machines. Concentricity is assured to 0.0001-inch accuracy because cutters rotate around the stock. **Turnmill Inc.**, 25450 Ryan Rd., Center Line, Mich.

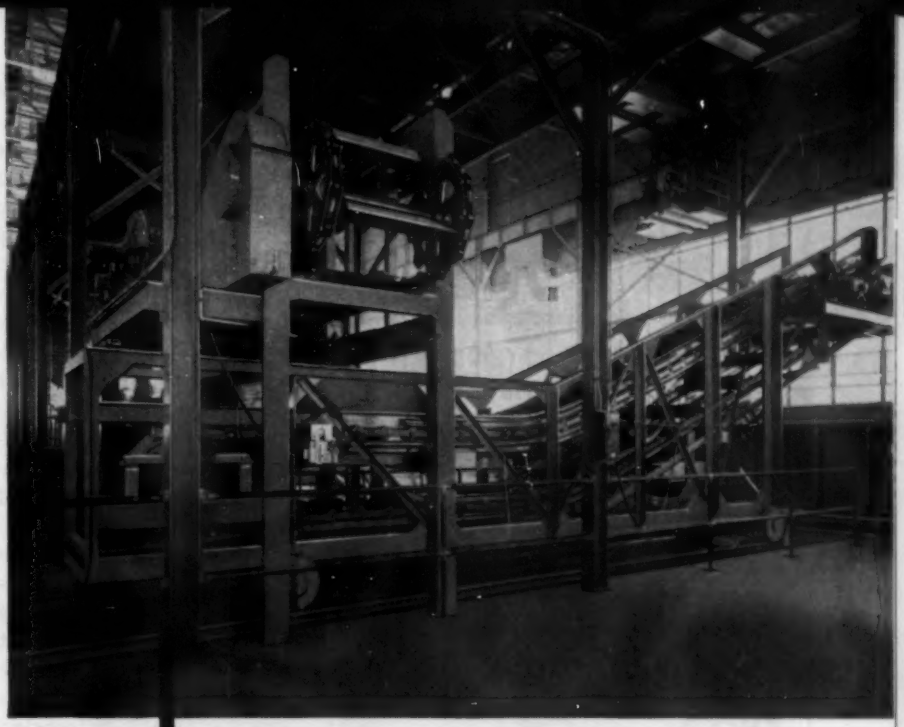
Circle No. **12** *on Reply Card*



No. 13—

Automatic Programming

Any sequence of plating operations can be made completely automatic through use of automatic programming equipment. Either selenium or germanium power units can be combined with program timing equipment for auto-



Saves $22,000 a year

Planet Pusher-Bar Conveyor Pays for Itself in Eleven Months

At a leading automobile plant, loading scrap from trim presses on to railroad cars formerly required a two-man crane and magnet operation.

Now . . . two Planet conveyors move baled scrap to waiting railroad cars *automatically* . . . saving $22,000 a year!

The system, which now loads an average of 12 cars a day, is engineered to handle a maximum of 105 cars a day. The retractable conveyor permits easy movement of the railroad cars.

If your plant has a scrap handling problem, get in touch with a Planet Engineer. Whatever your plant layout, he'll show you an efficient, compact, and economical way to minimize your handling costs.

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- CONVEYORS
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- FOUNDRY EQUIPME
- AUTOMATION
- STEEL FABRICATION

CIRCUIT CONTROLLING COUNTERS *with Automatic Reset*

FOR REVOLUTION, STROKE AND ELECTRIC COUNTING

THESE predetermining counters with instantaneous reset will automatically recycle a variety of single and multi-stage switch functions. Recycling operates without time lag at speeds to 5,000 rpm. The switching pattern repeats automatically as long as desired. The control circuit is an integral part of the equipment.

CYCLO-MONITORS

Used to control one or two switching events within a preset count-cycle. Replace unwieldy change gears, cam systems, timing chains, etc.—provide quick and completely flexible adjustment for changing requirements. Adjustment in one-count increments extends over a wide range of numbers. Available in a variety of models—*write for General Catalog of Cyclo-Monitors.*

PROGRAMONITORS

Same cycle range as Cyclo-Monitors, but also permit ANY NUMBER of intermediate switching events. Complex switching patterns of any countable sequence can be programmed and automatically repeated. Momentary or dwell switching—continuous or intermittent operation. Built-in control circuit can be opened or closed at any numbers. *Write for Bulletin 505.*

COUNTER AND CONTROL CORPORATION

5233 W. Electric Ave.

MILWAUKEE 14, WIS.

matic operation of any series of plating steps. A number of synchronous timers housed in a single cabinet with interlocking circuits and controls will start, stop and time any number of separate operations in any sequence, without supervision or interruption. Use of such timers, plus a motor driven autotransformer, controls the output in preset time intervals for complete prestrip and finishing operations. One application of automatic programming is in aluminum anodizing where the resistance of aluminum will vary in such a manner that the resistance will radically increase with time. Therefore, with automatic programming low voltage is injected at the start of operation, and voltage increase program is preset so that the increasing resistance and increasing voltage will maintain a fairly constant current. **Rapid Electric Co.,** 2881 Middletown Rd., New York 61, N. Y.

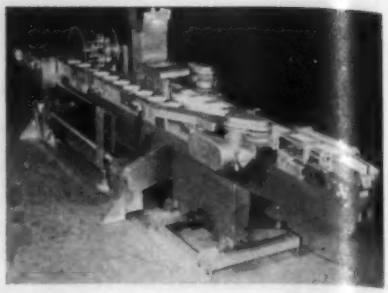
Circle No. **13** *on Reply Card*

No. 14—

Floor Type Conveyors

Range of objects from cans or baskets to cases stacked six high are transported by floor type conveyors. With this system, conveyors are set in the floor. Pits are provided for both take-ups and power units. First introduced in dairies, new conveyors are proving efficient, by conveying larger loads with less handling, in diversified applications. Conveyor is ideal on loading platforms, as illustrated, and can also be used anywhere inside a plant. **Mojonnier Bros Co.,** 4601 W. Ohio St., Chicago 44, Ill.

Circle No. **14** *on Reply Card*



No. 15—

Pie Packager

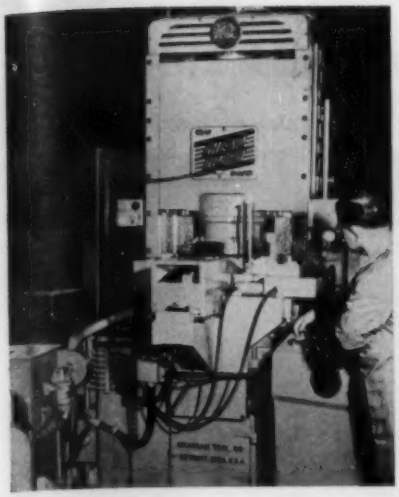
Designed to handle multiple lock tab cartons at speeds up to 200 units per minute utilizing only one operator, horizontal type automatic packaging machine is used to pack frozen pies. Powered by a 3 hp variable drive motor which operates both the packaging machine and the pie making machine, new machine is magazine fed and is designed for automatic hook up to either Colburn or Mayfair pie machines. Machine automatically sets up each carton. Built-in indexer receives 5-inch pies in double file from the pie making machine and transfers them into single file. Specially developed automatic tamper-perforator levels the top crust of each pie uniformly and produces the necessary perforations. Pies, under positive control, move along a guided conveyor and are inserted into moving cartons by means of angular positioned moving chains which cause the pie to slide easily into the open carton as the cartons and the pie merge. Carton is then simultaneously locked on each end by stationary plows. Each carton is held tightly in line between special lugs eliminating carton damage. End loading, mechanically locked cartons feature special construction for rigidity. Tapered end flaps eliminate overhanging edges and facilitate jam-free operation. **Marathon Service Co., Marathon Corp.,** Menasha, Wis.

Circle No. **15** *on Reply Card*

No. 16—

Gear Shaper

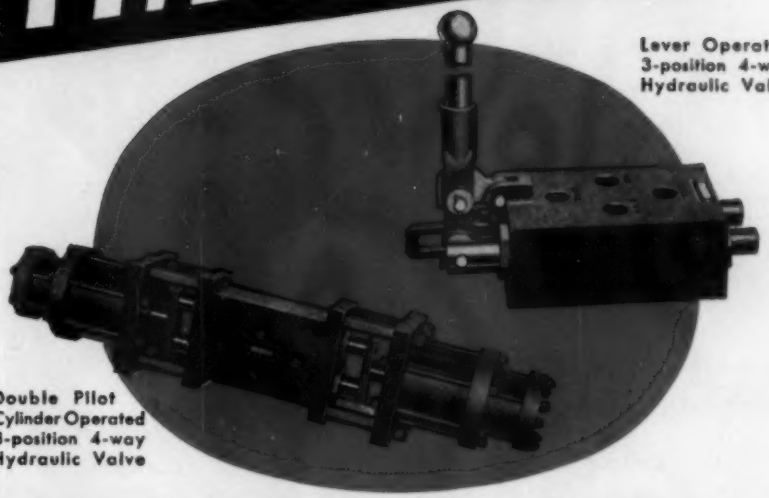
Completely automatic operation of line of gear shapers, including automatic size adjustments to assure continuous operation of these high production machines, has recently been announced. Complete operation includes automatic load-



ing, a gear washer for cleaning gears prior to inspection and a three-way classifier and control panel for 100 per cent size inspection and size control of all gears produced. Various combinations using one or more of these components can be supplied to suit a particular application. An automatic size control unit built into the machine and working in conjunction with the three-way classifier control panel, regulates total infeed of radial cutting tools. It acts to increase or decrease total infeed by means of electrical impulses fed back through the three-way gear classifier and control panel to size-controller as oversize or undersize gears are detected. When tools start to get dull, resulting in gears being consistently oversize, control panel shuts down the gear shaper for tool change. By shutting down the machine at the beginning of tool dullness, maximum production is maintained and less stock has to be ground off in resharpening. Automatic loader has magazine loading and uses both an indexing rotary table and a shuttle movement in its design. Loader is mounted so that it swings to one side for tool change. Finished parts are discharged into a chute. Magnetic chip separator removes chips automatically from cleaning fluid in the gear washer. Clutch-brake unit installed in the drive system stops the work ram reciprocating chankshaft within 1 degree. This feature assures precise positioning of work holding fixture for automatic loading operation. **Michigan Tool Co.**, 7171 E. McNichols Rd., Detroit 12, Mich.

Circle No. **16** *on Reply Card*

Quick-As-Wink® Hydraulic Valves



Hand and Pilot-operated Types for Water or Hydraulic Oils to 5000 psi.

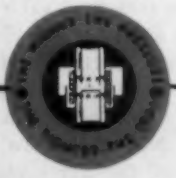
• Quick-As-Wink Hydraulic Control Valves meet the most exacting requirements. These valves are fully balanced in any position. Patented design includes hydraulically balanced U-packers. Packers are floated while crossing the valving ports, thus assuring long life, and expanded by internal valve pressure to provide a tight seal. Maintenance is extremely low and usually can be done quickly in the field, avoiding the delay of returning valves to the factory for servicing, or the need of maintaining large standby inventories. For long, dependable, trouble-free service, specify Quick-As-Wink Hydraulic Valves. Write for Bulletin No. 531 and the fully descriptive Data Sheets. They give complete details. Write *today!*

Ask us also about . . .

CAM OPERATED SINGLE PLUNGER VALVE ⅜" to ¾" sizes. Operated by rotating cam or land on reciprocating device.

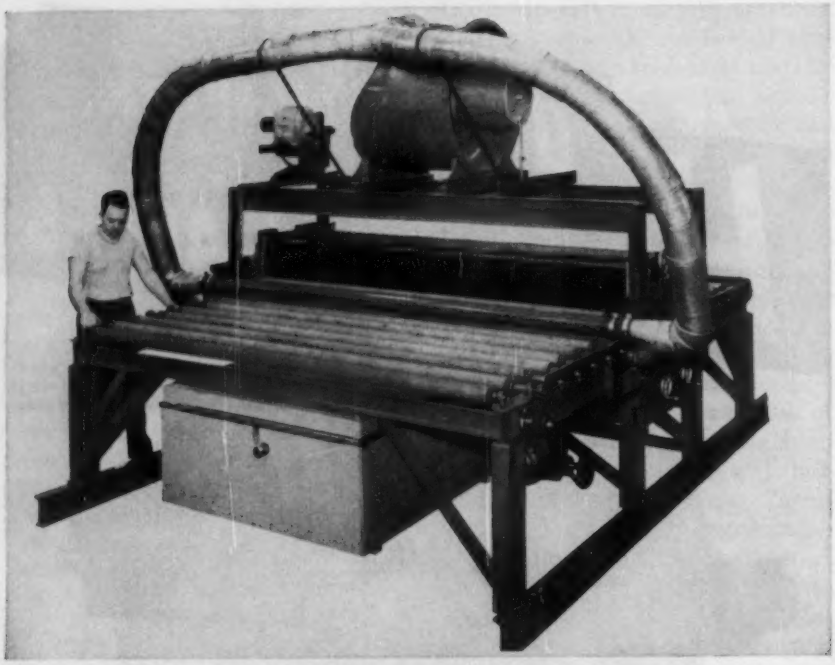
DOUBLE SOLENOID "O-TYPE" VALVE for pressures up to 125 psi. Widely used as pilot valves and for operating air cylinders.

Quick-As-Wink®
AIR AND HYDRAULIC
Control Valves



Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 2078 East Pershing St., Salem, Ohio

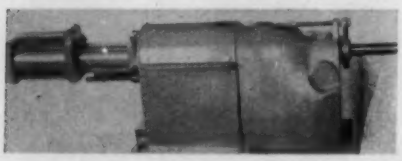


No. 17—

Automatic Glass Washing Machine

Uniform cleaning of both sides of plate glass immediately after the rouge polishing operation is performed by a mechanical rouge washing machine. Machine can process plates up to 8 ft wide at the rate of 12 fpm. With modifications, the machine can also be used effectively for the cleaning of oil or loose surface deposits from sheet metal. The plate glass moves along feed rolls into a hood where it is sprayed on top and bottom with a heated detergent and scrubbed between a pair of horsehair brushes. Spraying by the same detergent is repeated as the glass proceeds between a second pair of rotating brushes. The glass is then sprayed with a clear water rinse on top and bottom. Finally, it passes between two air manifolds, where a blast of air acts as an air squeegee to clean and dry the glass. The plate then moves on to a series of rolls which act as conveyors. **Fuller Brush Co.**, Machine Div., Hartford 2, Conn.

Circle No. **17** *on Reply Card*



No. 18—

Drilling Unit

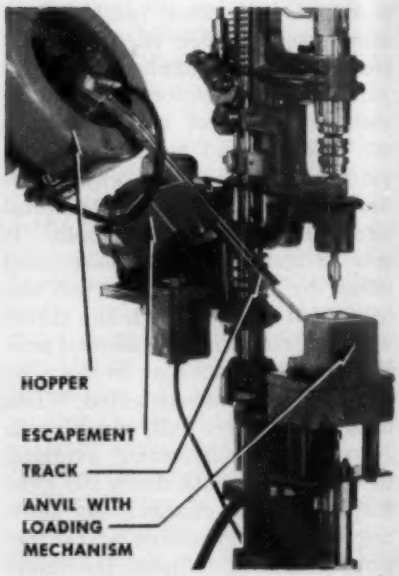
Variable spindle speed range from 600 to 4000 rpm is available with automatic drilling unit. Driller has an electric motor driven spindle and hydraulically controlled, air operated quill feed. Spindle feed and speed are under separate control for any combination of feed to speed. Spindle travel is powered by an in-line, double acting air cylinder. Feed rate is controlled by a closed hydraulic system. Threaded adjustable sheave on spindle in combination with spring loaded sheave on the motor provides a convenient, easily set speed adjustment. For close depth tolerance, a threaded positive mechanical depth stop is provided. In setting up a job, this is first adjusted for desired spindle travel. Limit switch provided is then set to trip a few thousandths before. Overtravel of the air cylinder, while the valve is reversing, will allow the quill to bottom on the positive stop and precise depth control is afforded. **Electro-Mechano Co., 261** E. Erie St., Milwaukee, Wis.

Circle No. **18** *on Reply Card*

No. 19—

Electronic Riveter

Designed to handle small studs and pins, either hollow or solid, new riveting machine features an automatic work cycle which includes hopper feeding for single-stage heading or beading of studs or pins on a combination anvil and pneumatic loading mechanism. Parts may have center distances as close as 3/16-inch. Standard machines are available with capacities for 1/16 to ⅛-inch studs and pins made of silver, copper, brass or mild steel. Studs and pins may be of any shape providing that their projections are suited to hopper orienting. They may be fabricated into parts with selective tolerances as close as 0.002-inch between head or bead and the part. Materials of the component present no limitation because easily fractured substances are accommodated without damage and waste. Design of the riveter combines high frequency blows with spinning. Spin-impact method permits cold flow rivet upsetting without structural change and weakening of the rivet. Controls are not limited to air pressure regulation alone on pneumatic-electric machine, since they can be adjusted for force and rate of impacts, duration of impacts, feed speed and depth of peen, and anvil loading speed. **Lemert Engineering Co. Inc.**, 206 E. Jefferson, Plymouth, Ind.



Circle No. **19** *on Reply Card*

SCIENCE AND ENGINEERING

AT LOCKHEED MISSILE SYSTEMS DIVISION

THE OPERATIONAL APPROACH TO RELIABILITY

Scientists and engineers at Lockheed Missile Systems Division apply an operational approach to Reliability in all phases of missile systems research, development and operation.

Under the Lockheed philosophy of Reliability, scientists and engineers combine their talents to study: human factors; training; design and operational safety; ground support and maintenance systems; airborne systems reliability; statistical methods; components application, including electronic, electrical, electromechanical and mechanical systems and environmental conditions.

Those possessing a high order of ability applicable to these areas of endeavor are invited to write:

Dr. Richard R. Carhart, Carl D. Lindberg, Reliability Staff Dept. Engineer, and Dr. O. B. Moan evaluate the functional and operational reliability effects of proposed revisions in the electrical power supply of a missile.

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***To arrange confidential interview, send resume to Box 104.**

AUTOMATION
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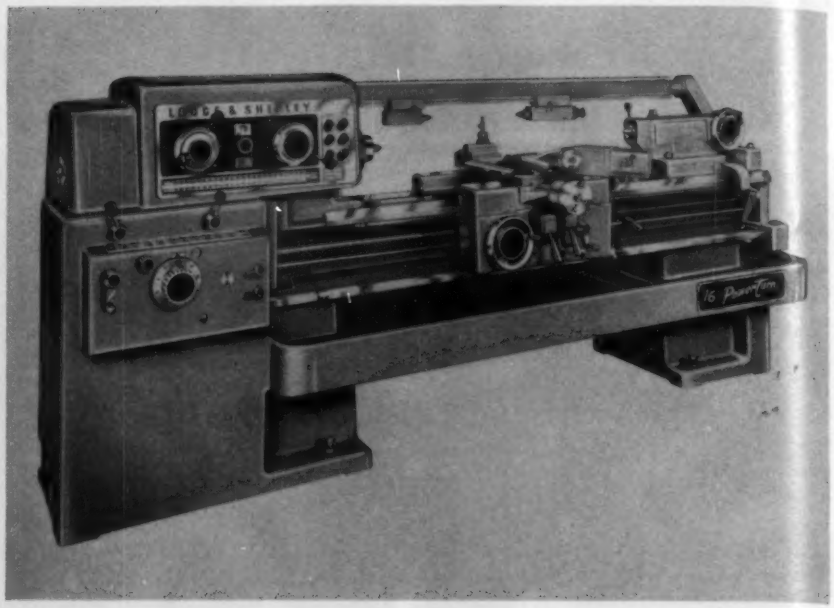
Cleveland 13, Ohio

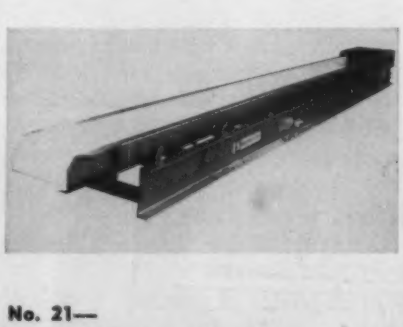


No. 20—

Automatic Contour Tracing Lathes

Design of new automatic tracing lathes produces smooth contours with uniformity of feed marks. Lathes are well suited to turning contours involving diameters or bores and faces connected by curves. Either turning or facing or a combination of both can be performed easily. New machine, called the 45° Copymatic, has new tracing mechanism and template support. Tracing stylus is base-mounted, simplifying work loading. Control is given to hydraulic cylinder which operates tool slide. Carriage operates at constant, uninterrupted speed for sensitivity. Hydraulic lines are enclosed in a flexible conduit. Copymatic is available in six models and sizes: Engine, Toolmaker and Gap, in 16 and 20-inch standard sizes. Another model, 90° Copymatic, is available in Engine, Toolmaker and Gap models in 13, 16 and 20-inch standard sizes. This machine has template support for either round or flat templates, positioned to clear top of lathe for workpiece loading and designed to simplify template arrangements. **Lodge & Shipley Co.**, 3055 Colerain Ave., Cincinnati 25, O.

Circle No. **20** *on Reply Card*



No. 21—

Pan Type Conveyors

Designed for handling hot, abrasive, corrosive, sticky or other difficult-to-handle materials, new line of conveyors features single sheet pan construction which makes them easy to clean. Positive action is assured by constant speed roller bearing eccentric and single or double heavy duty drive arms. Conveyors can be equipped with replaceable liners of stainless steel, mild steel, or aluminum. With addition of a metal cover and flexible connections, pan can be made dust tight. For operations such as scalping and separating materials or shaking out castings, conveyors can be equipped with grizzly decks, side extensions, double carrying surfaces, screen cloth, or perforated plate. Pan type conveyors are available in two types of pan mounting: conventional type, and vibration free balanced pan. In the balanced pan type the action of the pan is counterbalanced by weights at the ends

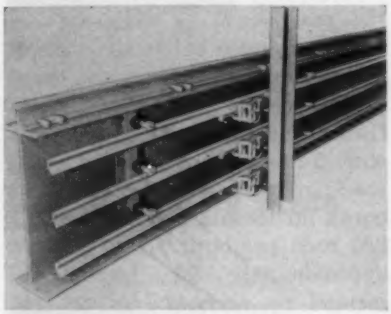
of the rocker arms, nearly eliminating thrust or vibration transmitted to the main frame and supporting structure. **Simplicity Engineering Co.**, Durand, Mich.

Circle No. **21** *on Reply Card*

No. 22—

Pantograph Conductors

Designed to aid in prevention of production holdups, aluminum inverted-Y conductors have sliding shoe collectors to handle heavy current requirements of overhead traveling cranes. Conductors are heavy aluminum extrusions, available in 300, 500, 1000 amp and larger sizes. They may be either side or overhead mounted to crane girders or runways by hangers especially made to permit conductors to float, disposing of the need for expansion joints and eliminating strain on the insulators, thereby minimizing their breakage. Cur-



rent collectors are built to give long, trouble free service on applications such as those found in steel mills, foundries, cement mills, etc. They are provided with a counterweight which maintains constant pressure of sliding shoes on the conductor bar. Each collector has two shoes which assure uninterrupted current flow. Shoes are in tandem and can be easily replaced by loosening one stud bolt for each. Because of pantograph motion and a ball and socket connection at the shoe support, positive contact will be maintained even if a bar becomes misaligned in either the horizontal or vertical plane. Conductors feature high capacity, low voltage drop, low reactance, light weight, rigid section, corrosion resistance, floating hangers and nonarcing collector shoes. **Cleveland Crane & Engineering Co.**, Wickliffe, O.

Circle No. **22** *on Reply Card*

EAGLE
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VITAL COMPONENTS IN MODERN AUTOMATION

Represented above are but a few of the complete line of popular EAGLE Industrial Timers and Counters.

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TRANSISTOR &
DIGITAL COMPUTER
TECHNIQUES

applied to the design, development and application of

AUTOMATIC RADAR DATA PROCESSING, TRANSMISSION AND CORRELATION IN LARGE GROUND NETWORKS

ENGINEERS
&
PHYSICISTS

Digital computers similar to the successful Hughes airborne fire control computers are being applied by the Ground Systems Department to the information processing and computing functions of large ground radar weapons control systems.

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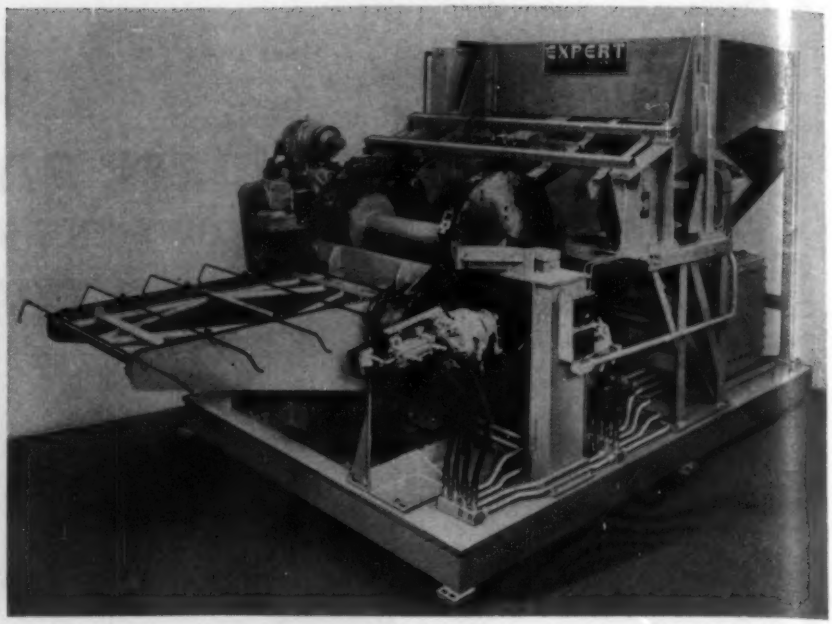
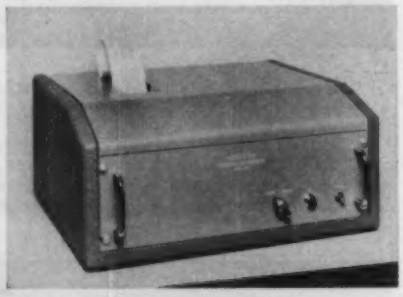


No. 23—

Steel Rod Bending Machine

Automatic bending machine produces up to two bends in each end of steel rods at rates up to 960 rods per hour. Machine has a mechanically operated rotary index drum that indexes rods from a feed chute to two bending stations. Inner and outer bends are produced in each rod end by bending dies powered by single-rotation, hydraulic rotary actuators. Finish-bent rods are carried out of the machine by a roller chain conveyor. Rotary actuators are adjustably mounted, enabling a wide variety of bend angles to be produced in each bend, as well as assorted plane relationships between the two bends in each rod end. Width of index drum and machine size depend on diameter and length of rod stock to be bent. Illustrated machine bends ⅜-inch diameter, 5-ft long heat treated spring steel rods to form automotive trunk lid torsion bars at a rate of 960 rods per hour. Two bends of approximately 90 degrees are formed on each end of the rod. One bend has a leg only ¾-inch long. **Expert Automation Co.**, 17144 Mt. Elliott Ave., Detroit 12, Mich.

Circle No. 23 on Reply Card



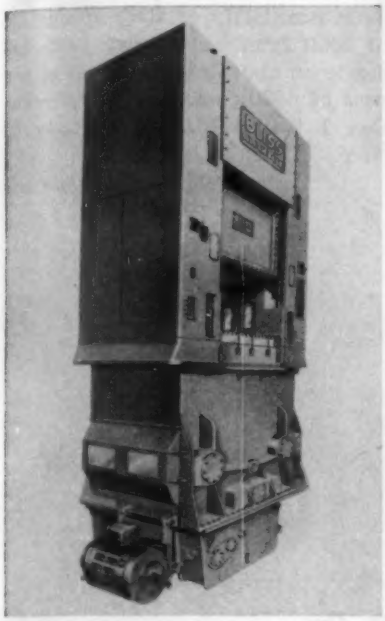
No. 24—

Scanner-Printer

New digital recorder is designed to transcribe electronic count data. Unit combines a scanner and printer in a single package to operate directly from any Berkeley counting equipment. Automatic readouts up to 10 digits are printed in arabic numerals on ordinary adding machine tape. Recorder can be modified to print time or code information on the same tape. Since it is able to print sequentially the total count accumulated by the basic instrument, recorder is ideal for long term stability checks, recording transients, or creating permanent printed records in digital control systems. Weighing only 60 lb, recorder consists of stepping switch, relay matrix, control and interlock relays, solenoid operated adding machine and a power supply. Unit can be coupled to all Berkeley instruments with four-

line binary codes, including frequency, timer interval and EPUT meters, electronic counters, and nuclear scalers. **Berkeley Div., Beckman Instruments Inc.**, Dept. 2835, 2200 Wright Ave., Richmond 3, Calif.

Circle No. 24 on Reply Card



No. 25—

Link Underdrive Press

Designed for operation in automated factories, underdrive system of new press provides a low crown that leaves ample head room for cranes in one-story plants. All piping and wiring for press controls, automatic work handling devices and maintenance power tool outlets have been built into the uprights. This not only results in clean, uncluttered exterior, but also provides a packaged unit that can be quickly installed with a minimum of pipes and wiring connections. Rockshaft mechanism has been redesigned so that it comes to within a few degrees of bottom dead center when the slide is in closed position, giving a mechanical advantage because it permits maximum force at the dies without bringing rockshaft to bottom dead center. Design uses a large, heavy rockshaft to withstand the powerful forces that are applied to it when the slide is approaching bottom. Link pins are large enough to assure that bearing pressures are never excessive even under most difficult operating conditions at

Other

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to Automation

Bring your production finishing problems to Paasche's Engineers and get the benefit of more than 50 years experience in designing units that will . . .

- PACE PRODUCTION
- REDUCE SPACE REQUIREMENTS
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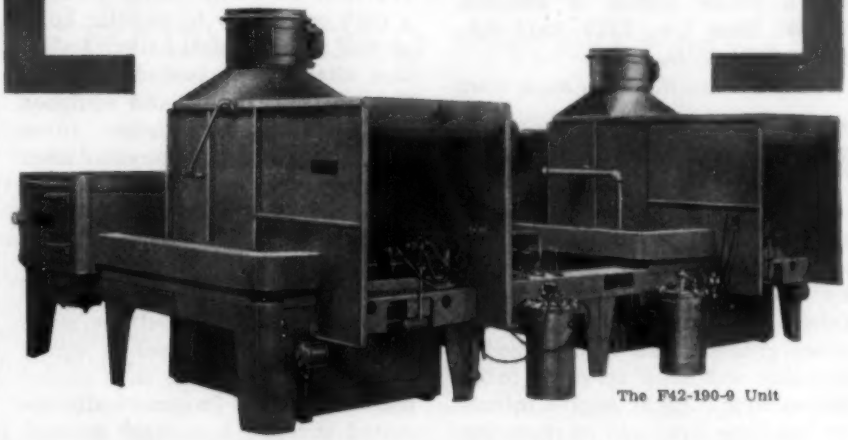
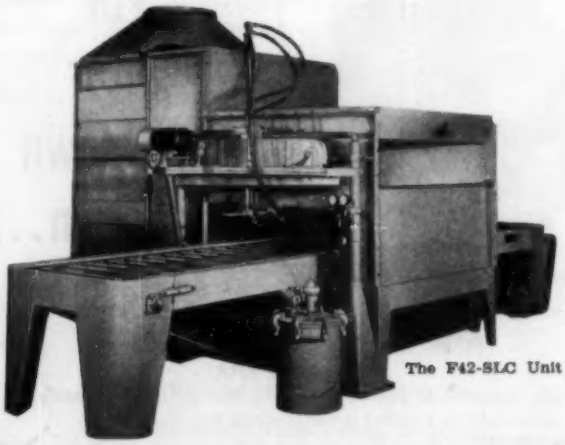


The F42-190-9 Unit

This Automatic Aircoating and Baking Unit is designed to coat and bake camera parts at 10,000 pieces per 8-hour day. A complete finishing system, contains two coating stations, water-wash booths and electrically heated oven.



The F42-SLC Unit

This Straight Line Conveyor Automatic Aircoating Unit is designed to coat wallboards, synthetic tiles, roofing materials and trays of small parts and hardware. Capacity 10,000 square feet per hour. Unit is complete with Automatic Oscillator and water wash booth.

Write for details and free survey of your finishing problems.

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DIVISION OF CLINE ELECTRIC MANUFACTURING COMPANY

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TORONTO 6, ONTARIO

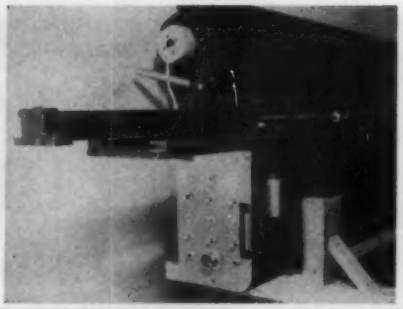
maximum rated tonnage of the press. Another innovation in the design of press is method of linking counterbalance cylinders to slide of press; connection is made through a swivel joint so that the slide may be trued-up horizontally without straining this joint. Press is fitted with two lubrication systems, one high and one low pressure. Counterbalance cylinders and cushion internals are lubricated automatically by an impulse timer that counts the number of strokes made by the press and actuates a three-way solenoid operated valve for a preset period of seconds. **E. W. Bliss Co.**, 1375 Raff Rd., S.W., Canton, O.

Circle No. **25** *on Reply Card*

No. 26—

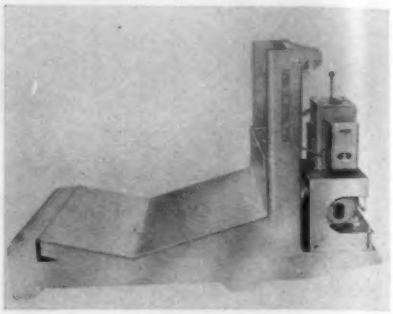
Pinhole Detector

Holes down to 1 mil diameter in opaque strip measuring 10 mils or less in thickness, are detected by redesigned pinhole detector. Device features sensitivity five times greater than former model. Detector will scan strip up to 48 inches wide. Light source intensity has been increased by replacing



21 small projection lamps with single mercury vapor lamp. Single light source has output of more than 25,000 ft-c. Light now provided on strip makes possible a high sensitivity to angular holes as well as to vertical holes. Detection chamber is coated with reflective white finish and equipped with six photomultiplier tubes placed at strategic intervals. Each tube is provided with a small neon light source which can be energized; a sensitivity adjustment is provided for each phototube. Neon lamps within integrating chamber are energized by pushbuttons, making it possible to simulate signal from a 1-mil hole for each photomultiplier tube. Pneumatically operated shutters hold light leakage to a minimum. Control panel is a ventilated enclosure mounted near the scanner. Connecting cable is provided, along with a burn-out relay which can be used to sound an alarm in case of light source failure. Detection of hole is indicated by operation of a plug-in type relay located in the control panel. Detector will function with maximum sensitivity at strip speeds up to 2000 fpm. Laboratory tests indicate an operating potential in excess of 6000 fpm. **General Electric Co.**, 1 River Rd., Schenectady 5, N. Y.

Circle No. **26** *on Reply Card*



No. 27—

Coil Lifters

Used to place coils on slitter mandrels and equipped with ball bearing mounted flanged wheels so that it can ride on tracks adjacent to the slitter, coil lifter is available with either a manual hydraulic lift or an electrohydraulic lift. Lifters have a V-shaped platform 30 inches wide by 41½-inches long with a lowered height of 8 inches and a vertical lift of 18 inches. They can handle coils weighing up to 4000 lb and having diameters up to 48 inches. Manually operated unit is equipped with double acting hand pump which requires 50 strokes for the full 18-inch lift. Electrohydraulic unit consists of an electric lift motor, a high pressure three-piston pump and a hydraulic cylinder. It is equipped with a throttle valve control for inching. Plunger of the lift cylinder is chrome plated and the spring loaded chevron type packings are self-adjusting for wear. Dual lift chains are also furnished. **Lewis-Shepard Products Inc.**, Dept. R-34, Watertown, Mass.

Circle No. **27** *on Reply Card*

For after shutdown protection...

AGASTAT®

TIME DELAY RELAY

Allows operation of auxiliary protective devices* after operating cycle is stopped. Easily installed in any electrical line.

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Long Hauls • Heavy Loads
Big Man-Hour Savings

ROBOT materials handling systems are here. Cleveland Tramrail has a wide variety of them in use in many plants. Some operate inside, some outside; some between machines, departments, or building floors; some between distant plants (as illustrated above). Some carriers travel between two points; others serve as many as 126 stations.

Operators are not needed for robot carriers. Pressing a button sends a carrier on its way. At the delivery point it stops automatically. After unloading and reloading, pressing another button returns it to the original station or to some other station as selected.

Cleveland Tramrail automatic carrier systems are available for loads of 1000 lbs. to 10 tons. They will lift loads to heights of 100 feet, if necessary, and carry them for practically any distance. Some carriers even unload and return automatically.

The man-hour-saving possibilities that Cleveland Tramrail Automatic Handling Systems offer you are tremendous—and there are other important advantages. It will pay you to get acquainted with this rapidly spreading idea of materials handling.

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Write us for your free copy of "AUTOMATIC DISPATCH PORTFOLIO" Gives data on a variety of cost-reducing automatic handling installations.

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CLEVELAND TRAMRAIL
OVERHEAD MATERIALS HANDLING EQUIPMENT

AUTOMATION new components

Parts, elements and devices designed for creating more automatic systems

For detailed information and literature, use card page 105

No. 28—

Remote Weighing

Weight data are transmitted to user's remotely located tabulating card punches, adding machines and other data handling devices through use of digital scanning electronic unit. With new device, weight data are no longer limited either to proximity to the point of origin, or limited in type of indication or recording. Weights can go anywhere and can be reproduced accurately in almost any form. Digital conversion is achieved with maintenance of normal accuracy of original, without electrical drift, nonlinearity or friction errors. Basic element in digital scanning electronic unit is a motor driven light source which scans lines exposed on a special chart. Output is a series of electrical pulses which pass through an electronic counter and translator to remote recording or indicating device. Scanner can be applied to current types of industrial dial scales. Typical applications of unit include listing and totalizing items passing over a monorail or roller conveyor; inserting of weight data in punch card billing records; recording of batch ingredients; and remote supervisory checking of weights. **Toledo Scale Co.**, Toledo 1, O.

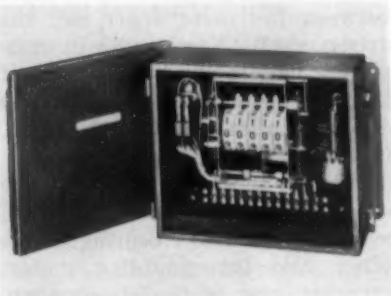
Circle No. **28** *on Reply Card*

No. 29—

Rotary Limit Switch

Designed for electrically controlling the starting, stopping, interlocking, motion, time, sequence and recycling operations on industrial equipment, mechanical rotary limit switching device provides precise cyclical control of nine electrical circuits. It offers an independent accurate adjustment of every control switch in the device through a range of 0 to 360 degrees by means of a calibrated thimble and stem arrangement similar to that in a micrometer. Adjustments are made from front of the device; adjusting assemblies are provided with positive locking means. Calibrated stroke or cycle position indicator is used in the devices and all individual adjustments are zeroed to this indicator. Switch units used in the device have both normally open and normally closed contacts in them; both circuits are wired to terminal blocks located in an integral junction box. Rotary limit switch has nine switches incorporated in it which are located radially around a single rotating helical cam. They are independently adjustable axially in respect to cam helix by means of external micrometer type adjustments. Switch will operate in either clockwise or counterclockwise direction with equal efficiency and life. **E. W. Bliss Co.**, 1375 Raff Rd. S.W., Canton, O.

Circle No. **29** *on Reply Card*



No. 30—

Batch Counter

Developed to control the number of items in a batch to be counted or measured, with control of quantity before or after an operation as desired, new counter can be preset at any figure within the range of five digits. Control

function—ringing of a bell, stopping of a machine, etc., can be made on a conveyor or at a machine or press. At each impulse a subtraction of one is made from the preset figure until the counter reaches zero. The counter then performs the control function. As further impulses are received, the counter adds one for each impulse until it reaches the original preset figure, then it again performs the control function. The subtracting operation then begins again. Counter requires no resetting at the end of each cycle and will continue to operate indefinitely until the preset figure is changed. Electrical control panel with release is built in. **Spencer Mfg. Co.**, 3253 N. Cicero Ave., Chicago 41, Ill.

Circle No. **30** *on Reply Card*

No. 31—

Overload Protector

Particularly useful on packaging equipment, conveyors, screw feeds, mixers, and other units vulnerable to jamming and overloading, new slip clutch overload protector was originally designed for inline drive between the drive shaft and the driven shaft. New model in company's line is used with takeoff drives, rather than inline direct drives. Called the Tork-O-Stat, unit has a hub on one side for double set screw connection to the drive shaft, and a shaft extension, mounted in a needle bearing on the other side for mounting pulley, sprocket, gear or flexible coupling. Tork-O-Stat parts are rustproofed, with internal parts heat treated. Unit is self-contained and is easily installed between a driving and a driven mechanism. Unit releases itself when an overload or jamming occurs and resets itself automatically when the overload or jam is removed. Models are available for 10, 15, 20, 30, 40 and 60 inch-pound torque rating and can be supplied with a variety of bore sizes. **Machine Accessories**, 6 E. Franklin Ave., Minneapolis 4, Minn.

Circle No. **31** *on Reply Card*

No. 32—

Intervalometer

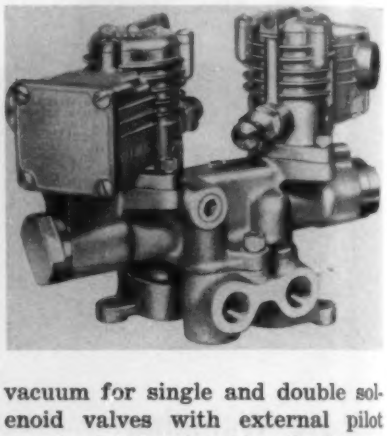
Developed as a standard method of supplying operating pulses for flight-test instrumentation, intervalometer is used in automation in the timing of processes, machine control and similar applications. It is also used for ballistics, missiles, fire control and other ordnance applications; in engineering and research, intervalometer has application as test control unit, process control unit and for time determination. Meter may be incorporated into systems, equipment or apparatus as a source of precision controlled intervals or timing pulses. Unit supplies 1, 2, 4, 5, 8, or 10 pulses per second which are selected at will by means of a control in front. Five additional continuous intervals of ½, 1, 2, 5, and 10 seconds which are independent of the selectable pulses and also of each other are brought out in separate circuits to output connector. Special pulse intervals and pulse duration may be supplied to fit specific requirements. **Photographic Products Inc.**, 1000 N. Olive St., Anaheim, Calif.

Circle No. **32** *on Reply Card*

No. 33—

Double Solenoid Valve

Requiring only momentary electrical contact for operation and capable of controlling up to 600 cycles per minute, pilot operated, four-way valve is called the double solenoid Speed King. With pilot solenoids and valve fully enclosed, unit is both moisture and dust proof. Solenoid coils, completely covered with molded epoxy resin, are unaffected by oil or moisture. Valves are bubble tested under water. Pilot plungers and valve stem are only moving parts; main valve has no springs. Speed King valves are available in ¼, ⅜, ½, ¾ and 1-inch pipe sizes, with foot or subbase type mounting. Pressure ranges in psi are: 32 to 200 air and 35 to 125 hydraulic oil for both single and double solenoid valves with internal pilot supply; 0 to 250 air and hydraulic oil for both single and double solenoid valves with external pilot supply; 50 to 125 water for single and double solenoid valves with internal pilot supply; within 1 inch Hg absolute



vacuum for single and double solenoid valves with external pilot supply. Pilot solenoid coils for operation on either ac or dc and any voltage can be furnished. **Valvair Corp.**, 454 Morgan Ave., Akron 11, O.

Circle No. **33** *on Reply Card*

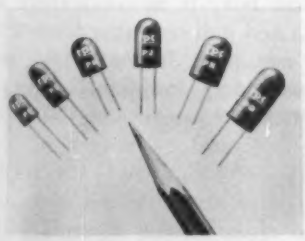
No. 34—

Angular Position Coders

Compact 13 and 16-digit encoders provide binary parallel code signals representing various shaft angles with accuracy better than ±10 seconds of an arc. Encoder is made up of a shaft, binary code disk, transistorized reading head with suitable preamplifiers and pulsed light source. High-precision 16-digit cyclic binary code disk used in encoder is main part of the unit. Disk is made of glass on which the binary code pattern is applied photographically. Each of the 16 tracks has a useable width of 1/16-inch. Readout is accomplished in 65,536 discrete steps,

boundaries of these steps being accurate to within eight parts per million in relation to each other. Special machine is used to produce photographic masters for these code disks. Machine is a circular dividing engine which operates on combination of photographic, electronic and mechanical principles to produce digital patterns of high accuracy. Reading head contains removable flash lamp, mirror for directing light from flash lamp through code disk and readout slit, and array of phototransistors. To accomplish reading of disk at any desired instant, step-up transformer is incorporated so that comparatively low voltage trigger pulse will flash the lamp. Output signals obtained are approximately 5 to 7 v at impedance of less than 1000 ohm, suitable to operate into transistor or vacuum shift registers, magnetic flip flops, or a cyclic to ordinary binary translator. Operation of encoder is maintained over temperature range of −55 to 85C. **Encoder Div., Baldwin Piano Co.,** 1807 Gilbert Ave., Cincinnati 2, O.

Circle No. **34** *on Reply Card*

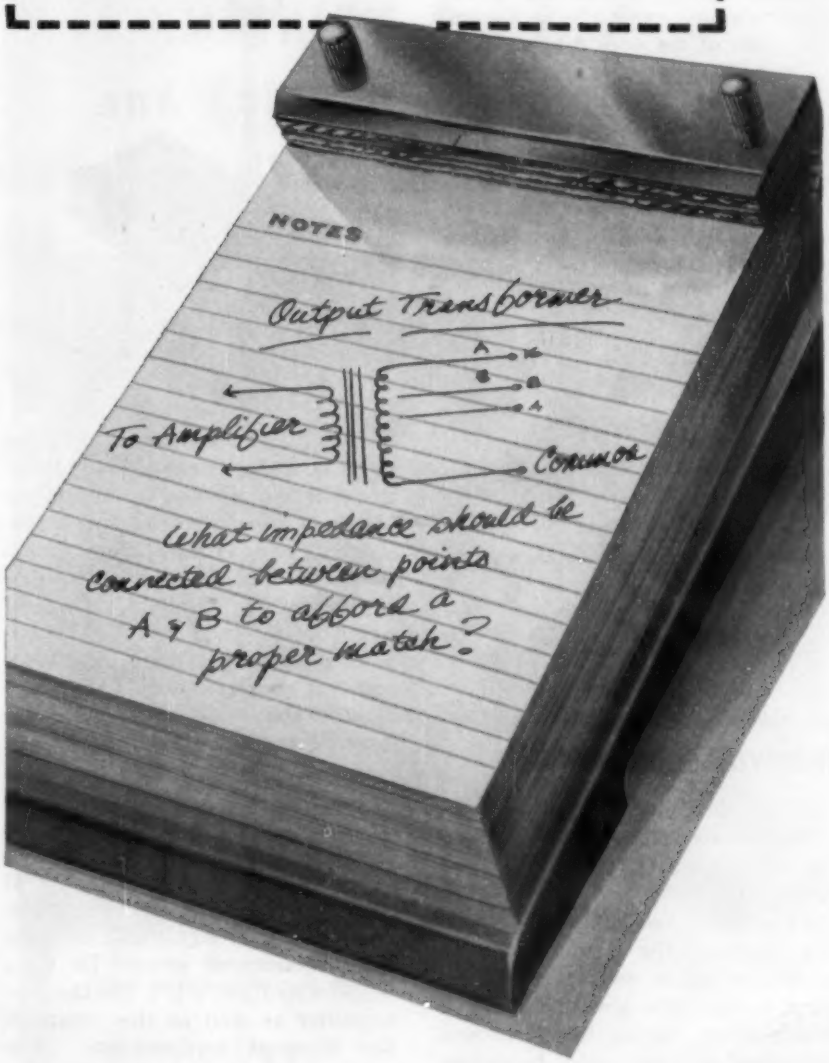


No. 35—

Miniature Resistors

Engineered for use with printed circuits, line of precision wire wound miniature resistors are single-ended units made for mechanized mounting on printed circuit panels with no support other than the wire leads needed. Resistors can be safely operated at full rated load in ambient temperatures up to 125 C. They are made with high

Is your Future a Problem?


NOTES
Output Transformer
To Amplifier
Common
What impedance should be connected between points A & B to afford a proper match?

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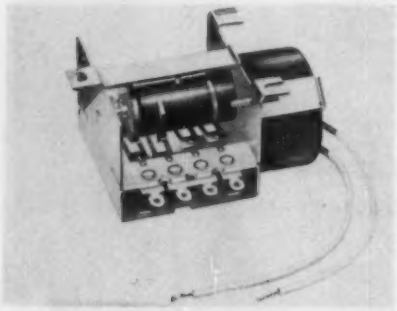
P. O. Box 1 Buffalo 5, N. Y.

temperature epoxy resins and resistance wire with special high temperature insulation. Sizes are available rated at from 0.1 to 1w. Resistors are available in a complete line of six sizes ranging from ¼-inch diameter and ⅜-inch long to ⅜-inch diameter and ¾-inch long. Available resistance values range from 0.4 megohm for the smallest size up to 3 megohms for the largest unit. **Resistance Products Co.**, 914 S. 13th St., Harrisburg, Pa.

Circle No. **35** *on Reply Card*



No. 36—

Interval Timer Switch

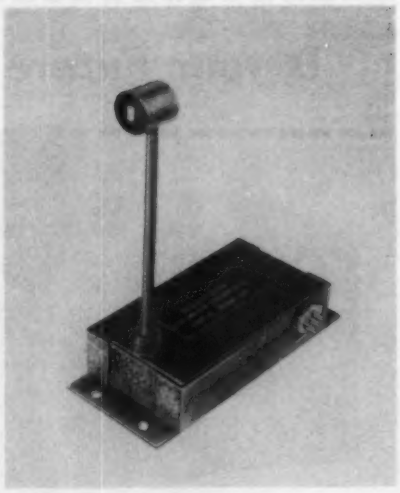
Four different circuits which generate four operations during an eight-second cycle are controlled by interval timer switch. As applied to an automatic vending machine, for example, it can control a typical sequence of dropping a cup into place, opening a filling valve, closing the valve and releasing a latch, and totalizing sales. Basic switch action can be supplied in varied lengths of total cycle, and with facilities for controlling varied numbers of circuits. It is applicable to many types of automatic sequence controls for machine tools and other relatively short-interval uses. Switch operates from standard 110v, 60-cycle power lines. **P. R. Mallory & Co. Inc.**, 3029 E. Washington St., Indianapolis 6, Ind.

Circle No. **36** *on Reply Card*

No. 37—

Detector Cell Units

Used wherever heat is a factor to be measured or controlled to handle processes in motion that are too fast, too hot, too inaccessible or too rigid in specifications



to permit direct contact with the product under control, heat detector cells are assisted by line of accessories which feature speed sensitivity, compactness, wide range, flexibility and low noise. Two preamplifiers are available, first of which is designed to retain maximum sensitivity at high impedance and low signal levels. Other preamplifier is designed to eliminate internal noise due to high ambient vibrations. Detector cells and preamplifiers require voltages that have been rectified and filtered free of noise and line voltage variations. New power unit accepts 115 v at 50 or 60 cycles, stabilizes line variations to supply adjustable detector cell requirement at ± 75 v to ±330 v and 200 v B+ for the preamplifier as well as the preamplifier filament requirements. Amplifier unit is matched to detector cell and preamplifier to drive its own indicating meter and provide a signal for an external recorder. Overall gain of amplifier is approximately 10,000. **Servo Corp. of America**, 20-20 Jericho Turnpike, New Hyde Park, L. I., N. Y.

Circle No. **37** *on Reply Card*

No. 38—

Control Key

Applicable to relay control of electronic computers, remote control systems and various types of automation equipment, control key has illuminated plunger which may be either locking or nonlocking type. Contact springs of control unit are each equipped with two palladium contacts mounted on twin nickel silver springs, and are arranged for direct friction free operation from the plunger. Key is so designed that regardless of stacking of spring leaves, spacing of multiple keys on panel can be uniform. Plunger uses a telephone switchboard lamp of any standard voltage up to 60 v ac or dc. Lamp may be operated on 120 v by providing a 2000 ohm externally mounted resistor. **Atocon Corp.**, Galion, O.

Circle No. **38** *on Reply Card*

No. 39—

Strain Gage Indicator

Designed to measure output of conventional strain gages, precision servo driven indicator consists of an indicator, servo amplifier and control box. It is completely self-contained and operates from 117 v, 400 cps line. Indicator is useful where many indicators must be photographed together. Feature of unit is counter presentation and small indicator size. Precision is high, with linearity of 0.2 per cent. Gage circuit used minimizes drift due to unbalanced thermal emf. No additional batteries or standard cells are required because amplifier provides bridge excitation. Indicator can be furnished with digital readout by addition of proper digitizer. It also can be adapted to measurement and readout of voltage, current, resistance, temperature, flow, humidity, and most other process variables. **Industrial Control Co.**, Wyandanch, L. I., N. Y.

Circle No. **39** *on Reply Card*

No. 40—

Solenoid Valves

Applicable in air conditioning, refrigeration, hot water heating, laundry equipment, dish washers, hydraulic pressure systems and automation installations of various kinds, solenoid valves have floating diaphragm to improve fluid flow. Valves are used for control of water, air, brine, light oils, industrial gas, freon 12 and 22, and other noncorrosive fluids at temperatures from 0 to 225F. Valves are available with or without manual operator that opens an auxiliary pilot port within valve and allows systems pressures to actuate the diaphragm in normal manner in event of electrical failure. **Jackes-Evans Mfg. Co.,** 4427 Geraldine Ave., St. Louis 15, Mo.

Circle No. **40** *on Reply Card*

No. 41—

Power Supply

Designed for use with photomultiplier tubes, counters, and other devices requiring a closely regulated, well stabilized voltage, Model PS-22 electronically regulated power supply operates from 500 to 1500 v, 1 ma and 2.5 ma. Use of a zero drain, thermally insulated battery

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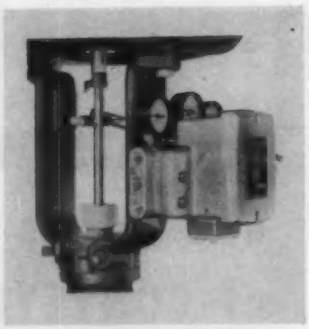
voltage reference allows long term stability and good absolute accuracy in setting output voltage. Both positive and negative are insulated from the chassis, and either can be grounded. Output voltage changes less than 0.01 per cent from 0 to 1 ma load. A 10 per cent change in input voltage causes less than 0.05 per cent change in output. Ripple is less than 0.003 per cent of output voltage. Front panel is standard relay rack mounting 7 by 19 inches. Extra set of output terminals is located at rear of instrument. **Scientific Specialties Corp.**, Snow & Union Sts., Boston 35, Mass.

Circle No. **41** *on Reply Card*

No. 42—

Valve Positioner

Designed for precise control action, accurate valve positioner overcomes friction and reduces line effects, speeding valve response to controller signal. Its applications include large volume diaphragm motors and processes where controller to valve distances are long. Positioner receives controller output signal at spring-opposed bellows which governs flapper-nozzle relationship. Back pressure in nozzle circuit acts on high capacity air relay to vary supply pressure to valve motor. Full pressure can be applied to motor on a controller output change of less than 2 inches of water. As valve stem moves to its correct position, lever connected to stem rotates shaft which, through spring and ball arrangement, restores flapper-nozzle relationship to a point of balance. At the turn of a disk, positioner can be adapted to either air-to-lift or air-to-lower diaphragm motor. Simple field adjustment permits valve sequencing. **Foxboro Co.**, Foxboro, Mass.

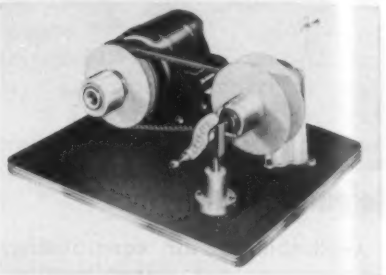


Circle No. **42** *on Reply Card*

No. 43—

Variable Speed Pulley

Compound drive that provides constant belt alignment through its entire speed range up to 8 to 1 ratio has been added to line of variable speed pulleys. Using a 1750 rpm motor, a speed range of 5550 to 690 is obtained at a rated ¾ hp. With 1150 rpm motor, a speed range of 3650 to 454 is provided at a rated ½ hp. Pulleys accommodate new NEMA motor frame shaft sizes and use a ⅞-inch top width or *A* belt as standard. Available in either spring loaded or manually operated design, they can be mounted on one side or alternate sides in accordance with in-



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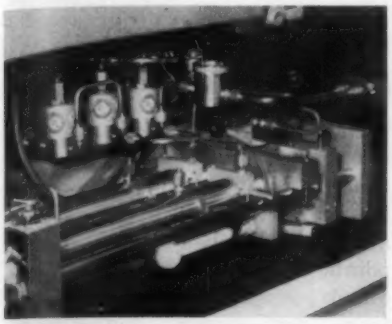
stallation requirements. Where mounted on one side, spring loaded design measures 6½ inches OD by 5 inches long, while the manually operated design measures 6 inches OD by 3⅜ inches long. Mounted alternately, dimensions are 6 inches OD by 3⅞ inches long and 6 inches OD by 3⅜ inches long respectively. **Lovejoy Flexible Coupling Co.**, 2951 W. Lake St., Chicago 44, Ill.

Circle No. **43** *on Reply Card*

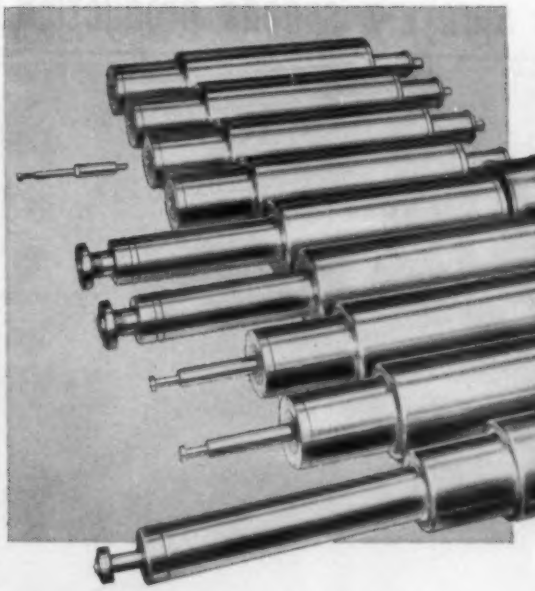


No. 44—

Infrared Analyzer

Automatic chemical analysis of difficult process streams in chemical and petroleum industries is possible with infrared analyzer. Typical applications are determination of CO and CO_2 in concentrations of 0 to 50 ppm, analysis of isobutane in mixtures of pentane and n-butane, and determination of HCl ethylene ratios. Infrared analyzer is dual-beam, nondispersive instrument which employs selective detectors and operates by measuring loss of energy of infrared beam in passing through the sample. Two separate condenser microphone detectors which may be independently sensitized are filled with gas which absorbs radiation only in the wavelength region useful in the analysis. This makes it possible to ignore unwanted radiation, and a high signal to noise ratio is obtained resulting in greater sensitivity and freedom from drift. Since the instrument is a positive filtering type, selective detectors do not respond to radiation outside useful wavelength regions and have a high inherent discrimination against other sample components that absorb outside these regions. **Applied Physics Corp.**, 362 W. Colorado St., Pasadena, Calif.

Circle No. **44** *on Reply Card*



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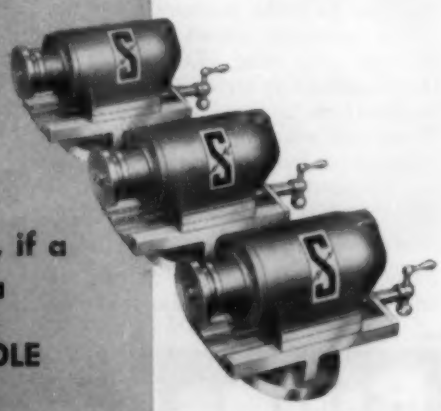

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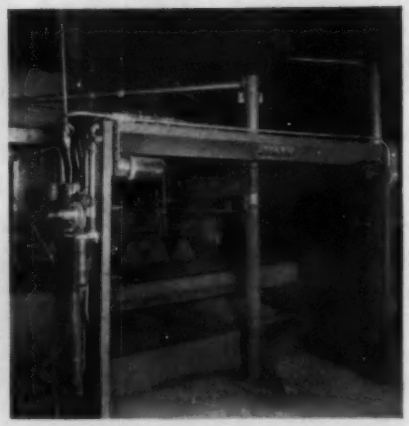
How automatic spraying speeds production

"...gives our production a lift of better than 60 per cent"

Fabricators, Inc. of Schiller Park, Illinois, has earned an enviable reputation as a finisher of Hardboard and Chalkboard. In this work it is important that the coatings be of uniform high quality, with the lowest possible material consumption.

To meet these requirements and to keep up with an increasing demand for their products, Fabricators, Inc. installed the Binks Automatic Reciprocating machine shown here. This machine is coating 16,000 sq. ft. of Hardboard a day with quality colored lacquer...an increase of better than 60 per cent over the 10,000 sq. ft. with previous equipment. This same equipment is coating up to 19,000 sq. ft. of Chalkboard with abrasive material, in an 8-hour day.



Binks automatic equipment can be adapted to almost any mass produced product. It not only speeds up production, but provides better and more uniform finishes. Material economies are substantial because overlaps, coverage and spray duration are mechanically controlled.

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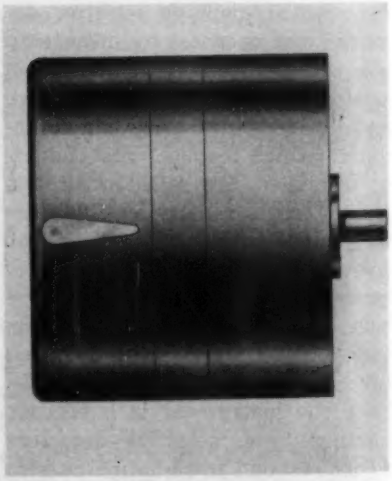
No. 45—

Machine Tool Switch

Designed for the machine tool industry, new switch features trigger fast snap action. The design has withstood 25,000,000 actuations. Unit has silver contact points which are reversible; terminal compartment is separate from the switch compartment. Roller and pin in the standard actuator are made of hardened steel for longer life, and cast aluminum case is gasketed for oil and moisture resistance. Switch has 70 degree overtravel and is available with a variety of actuators. It may be mounted at either side or from the top. Electrical rating is 25 amp, 125v ac-dc. **Acro Mfg. Co.,** Columbus 16, O.

Circle No. **45** *on Reply Card*



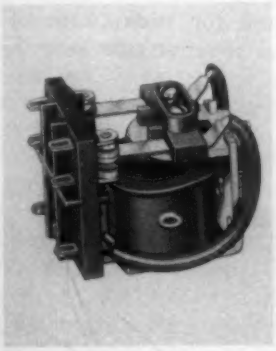
No. 46—

Brake Motor

Raising and positioning of heavy cutting blade, and positioning work on a lathe are among applications of brake motor. Unit is used

wherever short span power (5 minutes on and 5 minutes off) is needed to do the work of manual cranking and hoisting. Dimensions of unit are 8⅝ inches outside diameter by 7⅝ inches overall length. Starting torques of brake motor are up to 500 per cent of running torque, providing sufficient power to overcome starting inertias of heavy loads or those that are stuck or frozen. Brake motors are polyphase, totally enclosed, nonventilated and can be flange mounted in any position. Motors are available in ratings of 1/3 through 1½ hp; brakes from ½ through 25 ft lb, with 1 through 10 minute intermittent duty. **Reuland Electric Co.,** Alhambra, Calif.

Circle No. **46** *on Reply Card*



No. 47—

Midget Relay

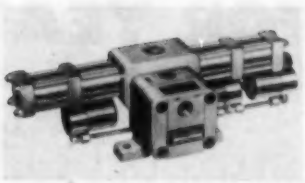
Applicable in computers, communications equipment, circuit projects, remote control units, automatic selectors, electronic controls and switching devices, Series 1200 ac or dc relay is rated up to 8 amp, at 115 v, 60 cycle, noninductive load. Rugged midget relay incorporates high power capacity and multiple contact combinations in small space. Dimensions are: 1 inch wide by 1¼ inches high by 1 11/16 inches long; weight is 1.9 oz. Contact combinations are available up to three pole, double throw. Solder terminals are molded in phenolic block, with barriers for over surface insulation. Unit is also available in variety of interlock arrangements formed with any combination of ac to ac, ac to dc, or dc to dc relays. **Guardian Electric Mfg. Co.,** Dept. 1200, 1621 W. Walnut St., Chicago 12, Ill.

Circle No. **47** *on Reply Card*

No. 48—

Power Operated Valve

Featuring power operation to forward, reverse and neutral, four-way power operated valve is used for air, gas, oil or water service, and is controlled by a three-position power attachment operated by air or gas. Designed for remote control and automatic operation, valve embodies rotating disk construction. Body is of molybdenum alloyed semisteel for freedom from



body leaks and has a chrome plated surface for smooth action. Integral disk and stem provide maximum rigidity and durability. **Ledeen Mfg. Co.,** 1600 S. San Pedro St., Los Angeles 15, Calif.

Circle No. **48** *on Reply Card*

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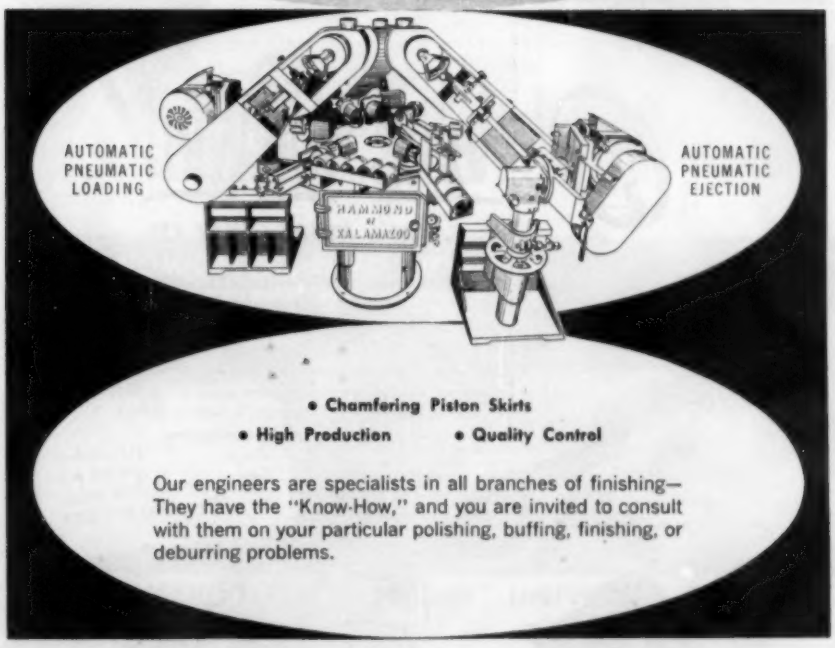

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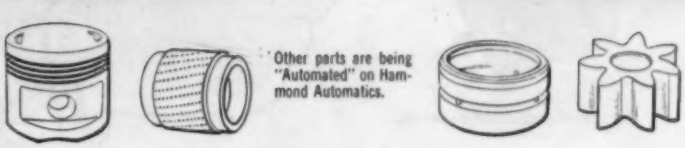
Our engineers are specialists in all branches of finishing—They have the "Know-How," and you are invited to consult with them on your particular polishing, buffing, finishing, or deburring problems.



Other parts are being "Automated" on Hammond Automatics.

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PROCTOR Weighing Feeds at Alexander Smith, Inc. precision weigh the stocks laying them in layers, which are picked before going to the roller distributor.

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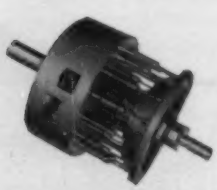
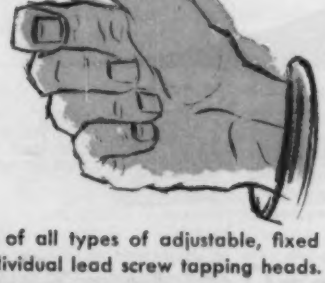
The heads shown here, moderate in cost, are for use with automatic chucking machines and turret lathes, for drilling or tapping operations. They provide, in most cases, that a part can be completely finished in one handling.

For automatic setup.

For semi-automatic setup.



For semi-automatic setup.



Manufacturers of all types of adjustable, fixed center and individual lead screw tapping heads.

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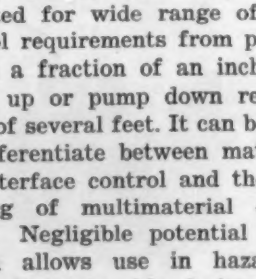
THE UNITED STATES DRILL HEAD COMPANY
BURNS STREET • CINCINNATI 4, OHIO

No. 49—

Proximity Relay

Proximity of moveable material, such as liquids, granular or solid objects, to the stationary probe affects an electronic circuit controlling a power relay. Relay automatically activates solenoid valves, power relays, motor starters, signaling devices, etc. Relay can be adjusted for wide range of level control requirements from plus or minus a fraction of an inch to a pump up or pump down requirement of several feet. It can be used to differentiate between materials for interface control and the controlling of multimaterial operations. Negligible potential probe design allows use in hazardous areas. Coaxial cable designed for heavy duty industrial applications is used to connect probe and case. Unit can be flush or surface mounted and will maintain accuracy. All operating components are contained in a sealed plug-in unit to eliminate time loss and wiring during maintenance. **Excel Electric Service Co. Inc.**, 2121 S. Western Ave., Chicago 8, Ill.

Circle No. **49** *on Reply Card*



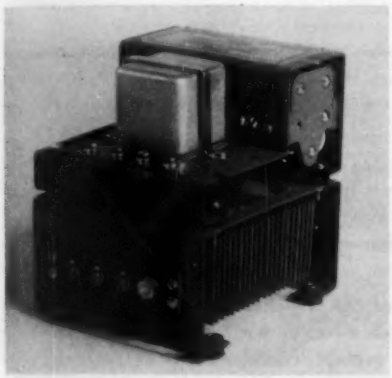
No. 50—

Miniature Torque Motor

Designed to drive hydraulic servovalves or other mechanisms which demand fast response and high output force proportional to input current, Model 21 torque

motor is rated at 9 lb force for 40 ma differential current. It may be driven from two miniature output tubes in push-pull, or from magnetic amplifiers. When magnetic amplifiers drive the motor, low impedance, high current coils are available which dissipate the same power. Stroke of the motor —±0.015-inch—is proportional to input differential current. Displacement sensitivity is ¾-inch per amp, or 20 ma for full stroke. Rugged 18-oz motor is assembled with steel dowels and will withstand severe vibration without damage. Armature is of balanced construction so that large lateral accelerations have little effect on armature position. **Raymond Atchley Inc.**, 2340 Sawtelle Blvd., Los Angeles 64, Calif.

Circle No. **50** *on Reply Card*



No. 51—

DC Motor Speed Controls

Designed to deliver stepless motor speed control from "dead stop" to "above base speed," dc motor speed controls feature compactness, reliability and low cost. Motor speed is set by operator and thereafter remains constant within 2 per cent in spite of line and load variations. Standard features such as dynamic braking, reversing, etc. are available. No electronic tubes are used in the controls. Speed sensing element is a high-gain, finger type regulator. Metalworking, machine tool, paper, printing, textiles and material handling industries will find the fully automatic dc motor speed control useful in their operations. **Electric Regulator Corp.**, Pearl St., Norwalk, Conn.

Circle No. **51** *on Reply Card*

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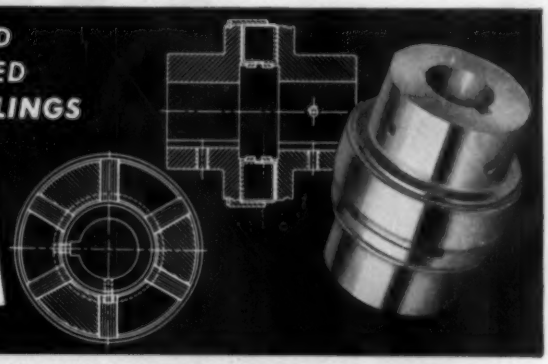
NON-LUBRICATED EASILY-ASSEMBLED FLEXIBLE COUPLINGS

Bores (max.) .....⅝" to 9½"
O.D. .....⅝" to 21½"
Wt. .....½ oz. to 1500 lb.
H.P. .....1/20 to 3000
Torque (static)..1½ to 5100 ft.-lbs.



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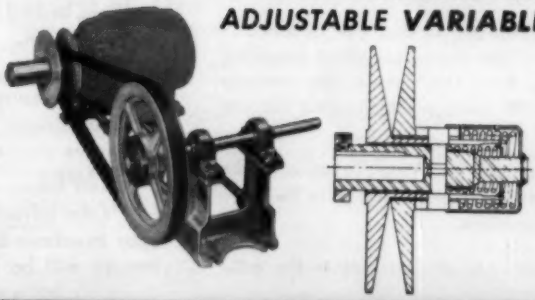
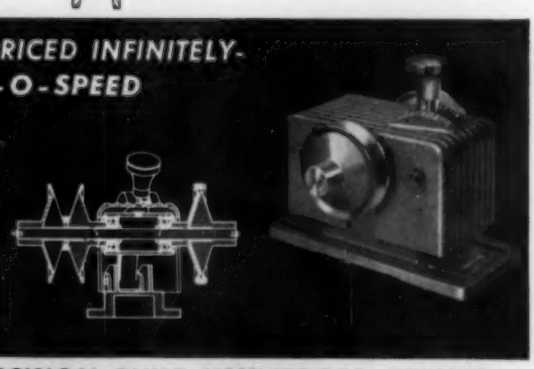


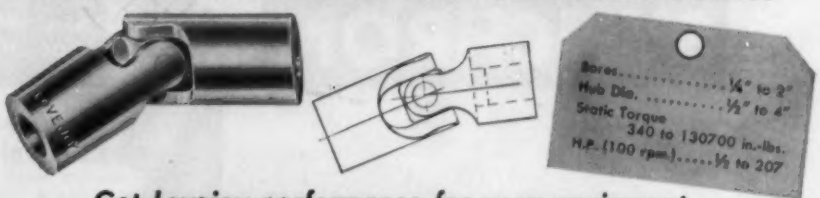
Bores (max.).....½" to 1⅛"
O.D. .....3" to 13⅜"
Belt Sizes.....A to 2⅜ TW
Speed Ratios.....1-1 to 8-1
H.P. (1750 rpm.).....¼ to 15

ECONOMICALLY-PRICED INFINITELY-VARIABLE SELECT-O-SPEED TRANSMISSIONS

Controls . Lever or Hand Wheel
Belt Sizes.....A to C
Speed Ratios.....1-1 to 10-1
H.P. (1750 rpm.)...½ to 7½



LIGHT-WEIGHT PRECISION-BUILT UNIVERSAL JOINTS



Bores.....¼" to 2"
Hub Dia. .....½" to 4"
Static Torque 340 to 130700 in.-lbs.
H.P. (100 rpm.).....½ to 207

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$\frac{T^P + F}{H^e} = YS$

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The Synchron Formula can help you cut production costs, make designs *work* the way you plan them.

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new CATALOGS AND LITERATURE

No. 52—

Crane Electrification

Cleveland Crane & Engineering Co., Wickliffe, O.—*8-page bulletin*—Complete conductor and collector systems designed for use in applications carrying currents from 300 to 1000 amp are the subject of bulletin 2021-A. Inverted-Y conductor systems discussed are side mounting type. Electrification is available for application on all makes of cranes and runways. Bulletin contains drawings, specifications and application data on the systems.

Circle No. 52 on Reply Card

No. 53—

Heat Detectors

Leeds & Northrup Co., 4934 *Stenton Ave., Philadelphia* 44, *Pa.*—*26-page catalog*—Radiant heat detectors for continuous temperature measurement to 5000 F and above are discussed in illustrated catalog. Theory of heat radiation measurements of actual surface temperatures and furnace atmospheres, construction of detectors and characteristics of units are covered. Complete assemblies for general and specialized applications such as temperature measurements in induction heating, glass feeders, protective atmosphere furnaces, baths of molten material and numerous others are illustrated and briefly discussed. Accessory items, indicators, recorders, controllers and pyrometers are also covered.

Circle No. 53 on Reply Card

No. 54—

Tube Fittings

Imperial Brass Mfg. Co., 1200 *W. Harrison St., Chicago* 7, *Ill.*—*20-page booklet*—Lubrication systems, coolant lines, instrument piping, air lines and similar uses are among the applications of tube fittings which have high vibration resistance. Fittings, which are available in brass or aluminum, are designed for use with copper, brass, aluminum, tinned Bundyweld, block tin, monel, everdur and other seamless metal tubing to make tubing joints which will withstand hard service and vibration. Booklet includes specifications and illustrations of various models of nuts, unions, connectors, female couplings, ball checks, elbows, and tees. Supplemental pamphlet discusses tube fittings and accessories for polyethylene and other plastic tubing.

Circle No. 54 on Reply Card

No. 55—

Tube Mills

Yoder Co., Cleveland 2, *O.*—*64-page handbook*—Discussion on the cost of tube mills, their operating cost, speed, production and minimum tonnage or footage requirements for profitable operation is aimed to answer questions of prospective tube mill buyer. Brief review of different tube making processes and complete description of cold forming, electric weld process, its development, possibilities and limitations are given. The design and construction of welding transformers is discussed; specifications and illustrations of different units comprising complete tube mills, and other general engineering data are also included.

Circle No. 55 on Reply Card

No. 56—

Computers for Limited Budgets

J. B. Rea Co., 1723 *Cloverfield Blvd., Santa Monica, Calif.*—*12-page bulletin*—Information on the Readix, an electronic computer designed for scientific computation, data reduction, business data processing and automatic systems is given in bulletin. Unit features alphanumeric input and output, all decimal internal operation, five types of input and output, simplified program techniques and 4000-word internal memory. Power requirements, dimensions, weights, operation times, number range and pulse rate information on various models are given; specifications and data on commands are also included.

Circle No. 56 on Reply Card

No. 57—

Conveyor Systems

Chain-O-Flex Corp., Franklin Park, Ill.—*8-page bulletin*—Flexibility, safety and economy in both installation cost and maintenance are features of conveyor systems discussed in illustrated bulletin. Conveyor consists of link chain moving in steel tubes; vertical links of chain carry loads with welded hooks. Minimum number of moving parts and elimination of wheels and bearings on the moving chain have increased economy of conveyors which are used in food processing, TV tube manufacture, painting lines, etc. Application photographs and schematic diagrams illustrate the bulletin.

Circle No. 57 on Reply Card

No. 58—

Industrial Lubricants

Jet-Lube Inc., 3093 *N. California St., Burbank, Calif.*—*8-page bulletin*—Technical information on the qualities and specific uses in industry for lubricants such as multipurpose greases, outside gear and track roller lubricants, gear oils with molydisulphide, chain and gear oil, antiseize compound, sealing compound and air-dry lubricant is included in bulletin. Specifications for various lubricants are also given.

Circle No. 58 on Reply Card

No. 59—

Silicon Crystal Diodes

Raytheon Mfg. Co., 55 *Chapel St., Newton* 58, *Mass.*—*17-page booklet*—Line of hermetically sealed silicon diodes which are designed for use as voltage references or regulators is discussed. Diodes have a peak inverse voltage rating from 3 to 225 v. Mechanical and electrical data, along with temperature graphs are included.

Circle No. 59 on Reply Card

No. 60—

Closed Circuit TV Systems

Dage Television Div., Thompson Products Inc., Michigan City, Ind.—*16-page booklet*—Remote, hidden, dangerous or otherwise inconvenient points can be brought into view with miniature industrial television systems. Specifications and features of components for such systems are given in illustrated booklet. Components include cameras, video monitors, line and distribution amplifier, audio-video mixer, remote control equipment, remote pan and tilt unit and lens turrets. Systems can be adapted to experimental work, instruction, or inspection and supervision aspects of industrial processes.

Circle No. 60 on Reply Card

No. 61—

Rotary Switches

Allis-Chalmers Mfg. Co., 1205 *S. 70th St., Milwaukee, Wis.*—*8-page bulletin*—Functions of rotary switches described in bulletin 14B8112 include operating such electrical instruments as ammeters, voltmeters and frequency meters; and controlling such electric equipment as circuit breakers, transformer tap changers, motor operated rheostats, and governor motors. Operation of switches is discussed and actual installations on vertical and bench type control boards are illustrated. Table of ratings, outline of dimensions and photographs of rotary switches for special requirements are included.

Circle No. 61 on Reply Card

No. 62—

Delay Lines

Helipot Corp., 916 *Meridian Ave., S. Pasadena, Calif.*—*8-page bulletin*—"Criteria and Test Procedures for Electromagnetic Delay Lines" is the title of technical paper No. 491. General types of fixed and variable electromagnetic delay lines are discussed. Common delay line distortions are illustrated; methods for correction are analyzed. Test procedures, both pulse and sinusoidal, and methods for measuring linearity and phase shift are described.

Circle No. 62 on Reply Card

No. 63—

Remote Control Assemblies

Kupfrian Mfg. Corp., 395 *State St., Binghamton, N. Y.*—*12-page bulletin*—Design and use of flexible shafts and couplings are discussed in illustrated bulletin. Units are used in receiver and transmitter controls, radio tuner control and other control applications. Tables of physical properties of flexible shafts and casings are included. More than 100 components, including terminal fittings, casing ferrules and nuts are illustrated.

Circle No. 63 on Reply Card

No. 64—

Versatile Gages

Republic Flow Meters Co., 2240 *W. Diversey Parkway, Chicago* 47, *Ill.*—*12-page bulletin*—Compact, self-contained measuring instruments for draft, pressure, differential gas pressure and temperature can also be used for receiving pneumatic impulses from transmitters. Features and components of gages are illustrated, with ranges and specifications included. Bellows and helix type gages are also discussed and illustrated in bulletin.

Circle No. 64 on Reply Card

HERE IS THE LATEST IN AUTOMATION "HOW TO"

NEW CATALOGS AND LITERATURE

No. 65—

Roller Gravity Conveyors

Lamson Corp., Syracuse, N. Y.—20-page booklet—Detailed information, specifications, application data and illustrations of roller gravity, wheel, belt and live roll conveyors are included in booklet. Factors in choosing correct conveyor units for particular application are discussed. Among these are the load and its distribution, grade, width, bearings and shafts, roll position, roll size and specifications, frames, supports, and accessories. Various types of belt conveyor systems are illustrated and explained.

Circle No. 65 on Reply Card

No. 66—

Automatic Surface Grinders

DoAll Co., Des Plaines, Ill.—24-page catalog—Variety of precision surface grinders for production grinding operations is discussed in catalog. Application photographs and brief discussion on use of automatic grinders in production of power steering equipment and color television components are included. Design features such as coolant system, variable speed wheel dressing feed, and slip ring adjustments on feed handwheels are explained. Accessory equipment for extending application of surface grinders is listed and described.

Circle No. 66 on Reply Card

No. 67—

File-Computer System

Remington Rand Div., Sperry Rand Corp., 315 Fourth Ave., New York 10, N. Y.—8-page bulletin—Magnetic drum storage method with Univac file-computer system provides a large-scale, high-speed random access internal memory at low cost per character. Discussion of system and photographs of off-line and on-line equipment are included in bulletin. Arithmetic computer, traffic control unit, program controller, random access internal memory and sequenced access external memory devices are also illustrated and discussed.

Circle No. 67 on Reply Card

No. 68—

Production Weld Tooling

Pandjiris Weldment Co., 5152 Northrup Ave., St. Louis 10, Mo.—28-page catalog—Photographs of equipment used in many steel fabricating industries such as construction, railroad, tank, pipe, automotive, ordnance, heating, shipbuilding, farm equipment and transformer are included in comprehensive catalog. Line of welding positioners, turning rolls, seamers, and special application production welding fixtures are covered.

Circle No. 68 on Reply Card

No. 69—

Electronic Controls

Dynamatic Div., Eaton Mfg. Co., Kenosha, Wis.—16-page booklet—Nontechnical, simplified information on installation, performance and maintenance of electronic speed control units is given in booklet. Principles used to accomplish stepless speed control of eddy-current rotating equipment, using an ac line as power source, are described in detail. Photographs, parts list and operating characteristics are also included.

Circle No. 69 on Reply Card

No. 70—

Fluid Control Valves

Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago 7, Ill.—12-page bulletin—Instrumentation, refineries, aircraft test cells, laboratory apparatus, pharmaceutical plants, compressed air, vacuum systems and precision flow control are among applications of valves discussed in bulletin No. 3037. Types covered include needle valves for accurate regulation of flow, toggle valves for quick opening and closing, midget diaphragm type valves, shut-off, blow-down, test, and quick disconnect type valves. Photographs, specifications and operating characteristics of various types are included.

Circle No. 70 on Reply Card

No. 71—

Magnetic Clutches and Brakes

Dial Products Co., 9 Avenue E, Bayonne, N. J.—8-page bulletin—Line of miniature, magnetic clutches and brakes are discussed and illustrated in bulletin. Clutches can be used economically where a simple disconnect or nonchattering brake is required. Special models are also available for continuous slip or for accurate tension or torque control. Selection information on choosing a clutch or brake, and operating characteristics are included.

Circle No. 71 on Reply Card

No. 72—

Wire Straighteners and Cutters

Lewis Machine Co., 3441 E. 76th St., Cleveland 27, O.—16-page booklet — High-speed straightening, cutting, feeding, chamfering and deburring are performed by machines which are designed to handle wire and/or rod in both round and special shapes in all types of materials. Nineteen models of straightening and cutting machines are discussed in booklet No. M 55-3, along with chamfering and deburring machine and handling reels. Chart presents size, capacity and speed information for both stationary cut-off and flying-shear cut-off type machines. Wire reel model and size chart, photographs of machines and operating information are also given.

Circle No. 72 on Reply Card

No. 73—

Electromechanical Components

Bowmar Instrument Corp., 2415 Pennsylvania St., Fort Wayne 4, Ind.—18-page booklet—Precise speed step-up and step-down for controls, actuators and indicating systems is possible with components illustrated and described. A universal gear train kit of 20 gear clusters is available for improvising gearing devices. Components covered include precision miniature speed reducers, universal gear heads, servomotor gear heads, motor adapter housings, mounting hangers, universal gear trains, right angle drives and angle counters. Specifications, some applications, photograph and dimensions of each precision component are given.

Circle No. 73 on Reply Card

No. 74—

Wrapping and Packaging

Battle Creek Packaging Machines Inc., Battle Creek, Mich.—16-page booklet — Continuous flow principle incorporated in line of wrapping and packaging machines provides high speed, ability to handle wide range of package sizes and products, and versatility in synchronizing with other packaging equipment or conveyors to provide automatic operation. Illustrations of machines used for packaging and wrapping foods, meats, prepared products, textiles, frozen foods and paper products are included, with brief descriptions given. Also discussed and illustrated are package making machines and volumetric filler.

Circle No. 74 on Reply Card

No. 75—

Control Systems

Automatic Temperature Control Co. Inc., 5200 Pulaski Ave., Philadelphia 44, Pa.—14 page booklet—Illustrated examples of automatic control systems used for industrial furnaces, plastic extruders, die casting machines, sequence control, sand mullers, batch feeders and numerous other applications are included in booklet S-10. Steps in obtaining an automatic control system—consultation, design, purchase, construction and start-up—are also discussed.

Circle No. 75 on Reply Card

No. 76—

Enclosed Presses

E. W. Bliss Co., 1375 Raff Rd., S.W., Canton, O.—32-page catalog—Presses designed to meet requirements of automated production lines are described in catalog. Specifications for models in six basic types of presses, from 200 to 2500 tons are covered. Among these are two and four-point single-action presses, two and four-point double-action presses, four-point single action underdrive presses, and four-point triple-action underdrive presses. Features described and illustrated include automatic lubrication systems, integral gear and eccentric units, motorized slide and blankholders, built-in die area lights, flush mounted air and electrical controls for operation of auxiliary press equipment. Numerous application photographs illustrate the catalog.

Circle No. 76 on Reply Card

No. 77—

Precision Springs

Hunter Spring Co., Lansdale, Pa.—10-page bulletin—Considerations in the design of precision springs are discussed and illustrated. Spring index, coil diameter variation, modulus and physical properties of spring materials, tolerances, and a comparison of cost and physical characteristics of spring materials are included. Line drawings, graphs and charts illustrate the bulletin which is designed for insertion in a loose-leaf book.

Circle No. 77 on Reply Card

No. 78—

Vertical Scale Indicator

Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Windrim Aves., Philadelphia 44, Pa.—12-page bulletin—Miniature instruments which are used to measure and control process variables such as temperature, pressure, flow and liquid level are described in bulletin 7202. Information on recorder, indicator and controller is illustrated with photographs and schematic diagrams. Operating characteristics, mounting information and specifications of instruments are included.

Circle No. 78 on Reply Card

No. 79—

Gravity and Power Conveyors

Standard Conveyor Co., North St. Paul 9, Minn.—8-page bulletin—Among types of gravity conveyors discussed in bulletin are roller and wheel conveyors and spiral chutes. Power-driven types include belt, live roller, vertical lifts, flexible chain, slat and push bar conveyors. Pneumatic tube systems are also discussed. Photographs illustrate actual applications of conveyors. Accessory items are covered, with pictures and sketches included.

Circle No. 79 on Reply Card

No. 80—

Lubrication Studies

Farval Corp., 3249 E. 80th St., Cleveland 4, O.—8-page bulletin—Answers to lubrication problems are given in case studies included in bulletin. Automatic centralized lubrication systems in a slitting and shearing line, forging press, ore pelletizing plant, and paper processing press are among examples discussed. Photographs illustrate each case study.

Circle No. 80 on Reply Card

No. 81—

In-Line Gear Drives

Link-Belt Co., Dept. PR, 307 N. Michigan Ave., Chicago 1, Ill.—16-page booklet—Speed reduction is the function of in-line helical gear drives discussed in booklet 2651. Load classes for over 250 applications, overhung load ratings, dimension tables, instructions for proper selection and cutaway views of both double and triple reduction drives are given. Backstops and flexible couplings are also covered.

Circle No. 81 on Reply Card

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(STARTS PAGE 73) (STARTS PAGE 91) (STARTS PAGE 103)

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LITERATURE BRIEFS

No. 82—

Numerical Control

Pratt & Whitney Co. Inc., W. Hartford 1, Conn.—4-page pamphlet—Automatic method of taking data, given by numbers in digital form, and translating them to machine operations is discussed in pamphlet 591. Dimensions, speeds, feeds and other operation information contained on dials, punched cards, tapes or other storage media may be fed into machine and can be translated directly into mechanical action. Unit discussed combines measuring system and mechanical unitizing system. Photographs illustrate jig borer and rotary table applications.

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No. 83—

Hydraulic Valves

Electrol Inc., Kingston, N. Y.—4-page pamphlet—First in a series of bulletins on hydraulic products, Bulletin 101 covers hydraulic valves designed for aircraft-industrial and mobile applications. Among models pictured and described are timing valve, main pressure relief valve, speed control valve, cut-out valve, selector valve, female check valve, male check valve, poppet type valve and pressure regulator. Application information and specifications of each model are given.

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No. 84—

Feed Units

Hartford Special Machinery Co., 285 Homestead Ave., Hartford 12, Conn.—4-page pamphlet—Hydraulic feed units which feature thrust above the ways near the tool load and cam feed drill units which feature faster cycling, narrow construction and flexibility are discussed in pamphlet. Specifications and photographs of units are included.

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No. 85—

General Purpose Scanner

Westinghouse Electric Corp., P.O. Box 2099, Pittsburgh 30, Pa.—4-page pamphlet—Designed for scanning or single-shot heating of workpieces up to 30 inches long, 10 inches in diameter, general purpose scanner is discussed in pamphlet 85-843. Shafts, axles, pinions, gears and similar parts can be processed at high production rates with scanner. Construction and operation data of unit are given; typical heating operations are described.

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No. 86—

Viscosity Measurement

Brookfield Engineering Laboratories Inc., 240 Cushing St., Stoughton, Mass.—4-page pamphlet—Accurate viscosity measurement instrument for continuous process quality control is discussed and illustrated in pamphlet. Unit can be combined with a standard receiver to perform numerous recording or controlling operations. Principles of operation, installation data and application photograph showing typical installation are included.

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No. 87—

Stationary Tachometers

Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.—4-page pamphlet—Speed measuring units which have new circuits and takeoff heads are described in pamphlet 105. Numerous combinations of indicators and takeoff heads to meet specific speed measuring needs are illustrated. Typical tachometer applications in a tensile strength tester, in an automatic welding machine and in an aircraft test stand are also illustrated.

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No. 88—

Variable Speed Drive Care

Reliance Electric & Engineering Co., 1088 Ivanhoe Rd., Cleveland 10, O.—Services and parts available for V-S Jr. electronic variable speed drives are discussed in pamphlet H-2104. Preventive maintenance program which may be set up is explained. Recommended replacement parts stock is listed in relation to number of units in operation. Photographs of typical parts included in replacement kit are given.

Circle No. 88 on Reply Card

No. 89—

Controllers and Regulators

Leslie Co., Lyndhurst, N. J.—4-page pamphlet—Devices which are used for controlled quality in power or processing plants are the subject of pamphlet 552. Discussion on when to use a controller includes illustrations and description of control pilots, level control, single and double-seated diaphragm control valves. Pressure reducing valves, temperature regulators, pump pressure regulators and operating valves are covered in material on when to use a regulator.

Circle No. 89 on Reply Card

No. 90—

Jet Pump

Allen-Sherman-Hoff Co., 259 E. Lancaster Ave., Wynnewood, Pa.—4-page pamphlet—Pumping a mixture of solids and water through a transporting pump line is the function of jet pump described in pamphlet Ea. Photographs, line drawings and cutaway views illustrate application of unit to hydraulic materials handling systems. Table of capacities and related specifications is also included.

Circle No. 90 on Reply Card

No. 91—

Ball Bearings

Miniature Precision Bearings Inc., Keene, N. H.—4-page pamphlet—Basic dimensions and dynamic capacities for over 300 standard radial ball bearings and 50 other standard ball bearings are illustrated and tabulated in pamphlet. Bearing materials, tolerances, operating speeds and load ratings are also discussed.

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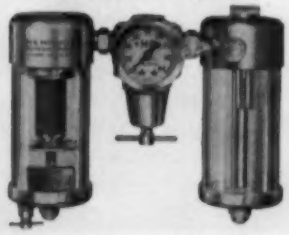

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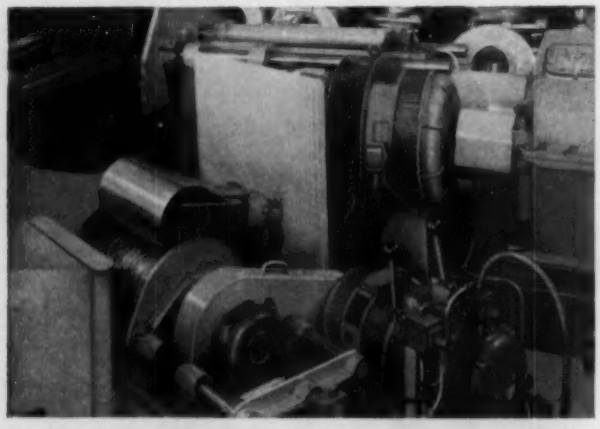

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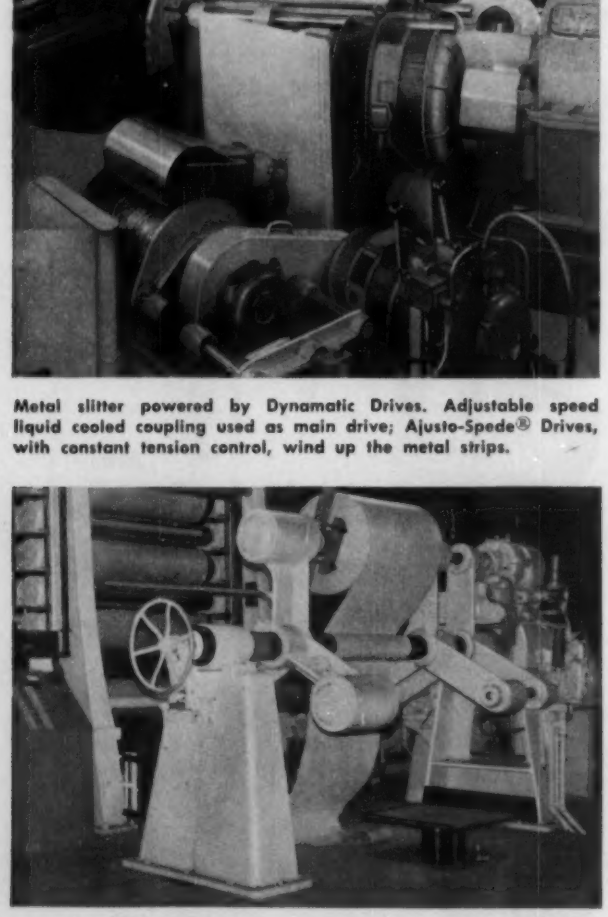

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AUTOMATION abstracts

CONTINUOUS GEAR PRODUCTION

By M. R. ANDERSON
Michigan Tool Co.
Detroit, Mich.

AUTOMATION has been with us for a long time. It goes back as far as the early days of the industrial age in the United States, or, for that matter, in the world. When a condition of work had to be made easier, people in the engineering fields came up with devices creating easier handling. Some were simple in form, such as small trucks or wagons, to transport material from one location to another. Some called for placing the parts in boxes and lifting the material to working height. These, of course, were the simplest forms of material movement from one operation to the other, but they were the start of modern automation.

Automation in the gear production field today in its elementary form starts with automatic loading added to a standard gear production machine. Groupings of these machines are arranged so that an operator can conveniently load the chutes—automatic cycling does the rest. Parts are discharged onto belt conveyors or into tote boxes.

Next is the continuous gear production line—from blank to finished gear without being touched by human hands. One such line is in operation—others are following in rapid succession. This is now the fastest growing type of automation. In this paper we shall also touch upon devices incorporated in the modern standard machines to eliminate human errors in loading and inspection. Operators are not as easily trained to avoid errors in our manufacturing shops today as under the educational apprentice programs of yesterday.

Line automation is primarily built upon the principle of having more or less standard machines "customized" with automatic loading devices and controls so a single product can be completely machined. This enables us to group them through a series of feeders or conveyors connecting the operations. Since the cutting cycles of some of the operations due to their nature take more time than others in the line, automatic storage stations are required to provide a reserve to equalize various time cycles.

Hoppers are provided to put the parts into the feeders properly. This prevents parts going in upside down or having the wrong end of the part going through the chute, clogging it. These loading chute, clogging it. These loading trolling fingers to set the parts so that we are able to get them into the feeding chutes in the proper orientation.

Other types of conveyors include gravity chutes, belts and elevator type lifters. All of these are used with limit switches or electric eyes that control the releasing of the parts from the loading chutes and hoppers as required. The electric switches are connected to central control panels where the timing can be controlled whenever the loader on a particular machine calls for more parts.

In the Automation Business

In reviewing our own history in connection with automation we recognized that we were entering an entirely new field. When we started to combine processes we were no longer dealing only with machine tools. We were also in the business of building automation.

We found that we had to build inspection devices to check parts in transit from one machine to another. Parts have to be checked for size, helix angle, and runout. Roots of the gear teeth are probed to be sure that parts do not come through with teeth deformed in the previous cutting operation by a broken tool or other errors.

Prior to the introduction of these automatic devices, most checking of gears had been manual. If gears did not pass inspection the operator stopped the machine. Now however, the automatic checking device itself has to be able to stop the machine before it turns out too many defective gears. Each machine thus operates as an integral self-contained unit with its own continuous feeders supplying a part to the machine whenever the loader calls for it.

Gear classifiers, having very accurate master gears as well as probing fingers built into them, must receive parts from the cutting operation free of chips or dirt. This involves the need for washers. In looking over available washing equipment we found, in general, that none had been built which would clean gears as rapidly as required, so designing and building gear washers was another new type of business that automation got us into as builders of machine tools for gear production.

Now we come to the next complication, one which we found in the hobbing, gear-forming and finishing operations. We had to incorporate a satisfactory means of automatically adjusting machine settings by feeding back informa-

tion on errors from the classifier to the machine's electric control panel. Compensating mechanisms were incorporated in the machine so that it would automatically readjust itself on the basis of these signals.

The machine has to be able to adjust itself automatically if a gear is machined undersize or oversize. It does this usually on the second gear coming through. Adjustment can be initiated by the second, third, fourth or fifth consecutive off-limits part, and it can also be automatically initiated if rejects should exceed a predetermined percentage of parts being produced. The nature and extent of the adjustment and its signal depend on how precisely the particular gear being produced needs to be machined. Dials also can be preset to make specific adjustments for tool wear or temperature changes.

Each producing unit consisting of machine, checker, control and washer, should operate as close as possible to its maximum fixed rate. Using the hobbing machine as an example, an integrated line normally may have from 4 to 12 such machines feeding one shaving machine. This is because of the faster operational speed of the shaving machine. An answer to correlating the supply from various machines having different cycle times is the zig-zag type conveyor which functions as a storage cabinet. It is unusual in that it need not be filled with gears for the unit to be or to remain operative and have gears come out of it. With this type of reservoir it is possible for one piece to travel through the complete automatic gear production line without any holdup. If there is a stored quantity we draw from this cabinet as and when required by the next operation.

In the block layout of *Fig.* 1, an actual line being designed by Michigan Tool for one of the major automobile companies is shown. This Gear-O-Mation line will turn out about 800 automotive pinions per hour and will be 1200 feet long —almost a quarter of a mile.

Automation Improvements

Although modern machines are of heavier construction than in the past, future machines will be designed for still greater rigidity. This is because of the ever increasing emphasis placed on accuracy, coupled with the requirement that machines be able to operate at peak capacity practically 24 hours a day. Already, modern automated machines do not need the minute-to-minute attention required by the older manually loaded machines.

Tool life now appears to be one of the limiting factors in automation and new studies must be made of this factor. Another point we would like to bring out is that despite the progress we have made already with controls, more and better warning signals, both electronic as well as optical, must be incorporated into future equipment. We probably will find ourselves using more tape controls for repetitive operations in various machines. Possibly we will be using a punch card system such as has been used successfully in experiments on quite a number of other machines.

Automation experience suggests the desirability for more rigid design of chutes as well as the inspection equipment so that these can stand the "gaff" of heavy production.

Automation will perform an additional important function in assuring the control of the analysis of the steels that go into gear blanks. An axiom in the gear industry is, "Good gears come from good steel." Poor steel as evidenced by poor machineability, undue tool wear, or excessive distortion is spotted more readily through 100 per cent check-

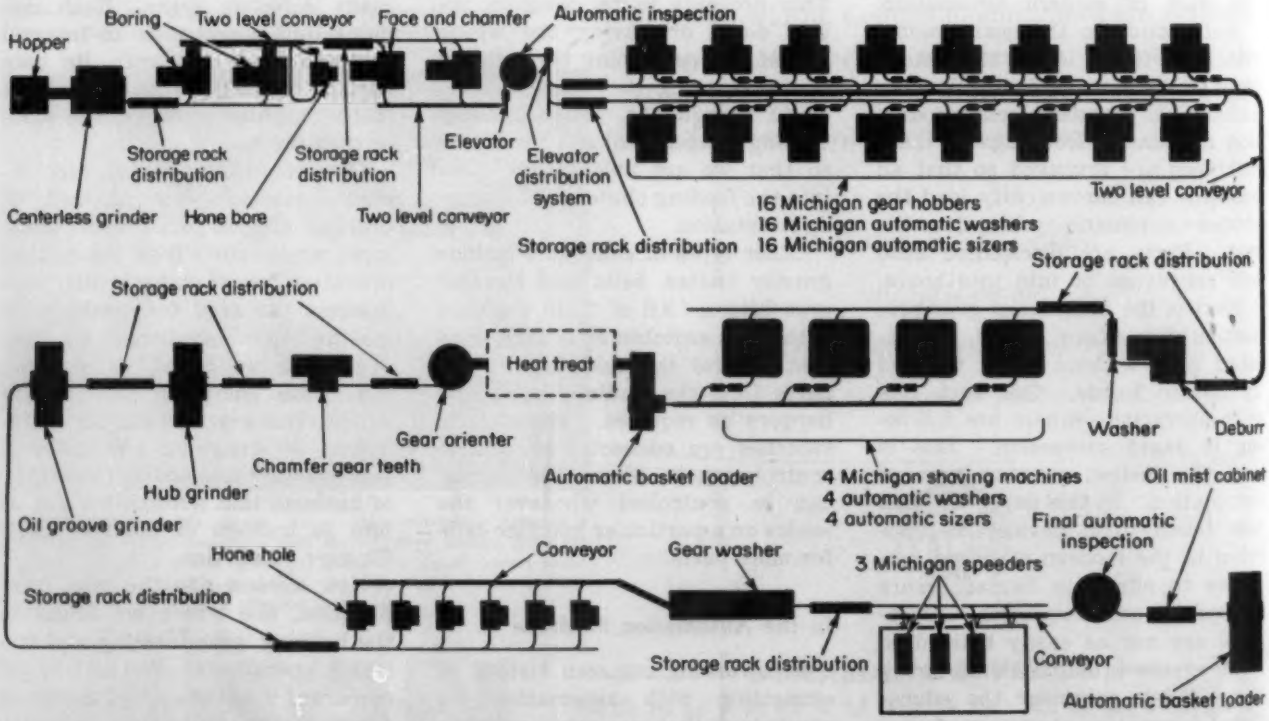

Fig. 1—Blanks are placed in the hopper at the beginning of the line and finished tested gears, packed in baskets and ready to go to assembly, are taken from the end of the line.

Berkeley news notes

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by Hugo Martinez

Presented at National Conference on Industrial Hydraulics October 27, 1955

Data File 121

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That sums up what we are facing in the components of the automated machining line.

There is still one important question: Where should we use individual automated machines and where should we use line automation? Naturally, neither type of automation is recommended unless you are producing hundreds or thousands of a single gear per day. Otherwise, you are putting too much money into equipment that can't be used to a degree approaching its capacity. However, if you have high volume gear production, we strongly recommend that you at least investigate automation to determine whether or not such an installation would be practical in your plant. Builders of gear production machines will be glad to work with you on this.

In this connection it is well to remember that standards not only for equipment but for the gears themselves will be affected by automation. As an example, our own engineers are now in the midst of preparing a new set of standards for rolled splines and serrations. These standards will be presented to the American Gear Manufacturers Association and the American Standards Association for their consideration. Their adoption will facilitate forming of the teeth and assure improved physical qualities for the splines.

Such changes as have already and will continue to originate due to automation will probably affect most gear manufacturers, including those who cannot use automation in their production. In our collective efforts to improve gear production methods, we may find that we will be able to take advantage of much closer tolerances than we have in the past in all types of operations in all quantities.

From a paper entitled, "Automation in Gear Production," presented at the Diamond Jubilee Annual Meeting of ASME in Chicago, Nov. 1955.

SMALL BUSINESS AND AUTOMATION

By PAUL B. WISHART
Minneapolis-Honeywell Regulator Co.
Minneapolis, Minn.

IF we sense a greater urgency today in the study of automation and of its impact upon business, that is because more people understand it, more people are actively urging its adoption, more companies today have the money to utilize it where it pays its way, and all competitive enterprise is affected by the forces exerted by those who are expanding their use of it.

Small business, particularly, must expect that its course will be altered by this growing use of automation. Small business faces two alternatives. The first is to be caught flat-footed, forced to fight rear-guard actions, attempting to compensate for or counter new competitive conditions. The second is to anticipate, through careful study of what is going on in the economy and in the particular industry, and to plan a realistic course, thereby gaining advantage of early action and having the best possible chance of minimizing likely competitive pressures.

There is a significant point in the government's recent report that American business estimates that two billion dollars more this year will be spent specifically for modernization than was spent for this purpose last year.

Because automation plays a major role in the modernizing of plants to meet the competition of streamlined new facilities, and because small business in the aggregate will contribute a healthy slice of the 27 billion being spent for plant equipment in 1955, there can be no question but that small business is rapidly adopting automation methods. The individual examples may not be as visible as those developed by big companies, but the men who run small businesses are just as keen; and their bankers, you can be sure, are backing their judgment.

You can hardly mention the words "small business" without implying conflict with big business.

In fact, we talk a lot about small business' fight for survival. This is exaggeration, because we know full well that big business will not take over small business in this country or anywhere else where our type of free enterprise, competitive economy is preserved.

While this is true in the overall, we harp on the conflict because each small business in a competitive industry feels keenly the threat of the larger business which has the financial resources, the managerial and technical talent, and frequently the sheer dynamism to outperform small business.

You are familiar, as I am, with the major circumstances that determine the success of a small business under competitive conditions. Price is first. We all know some small companies can outperform the big ones on price. Lower overhead, greater flexibility, more direct and possibly more enthusiastic supervision, geographical advantages—these are some of the reasons. I know that in the electronic industry many of the components are supplied by small companies, each specializing and doing a remarkable job of low-cost production based on a substantial volume sold to hundreds of customers. Few if any of these customers would find it worth their while to try to compete.

Another advantage is product quality. Here again, the large company, even with all of its engineering resources, frequently finds that it cannot match the quality of the small specializing company.

There are many other factors. I would add only two. The small company which understands and concentrates on its own field frequently thinks further ahead in the development of that product line than does the large company where pioneering effort is likely to be diluted in the whole program of the company's varied interests. Finally, the most productive original ideas are likely to reach the top quickly in a small operation, to get a full hearing, an adequate trial, and a successful application to a problem that looms large in the small company.

Ideas still spring from individ-

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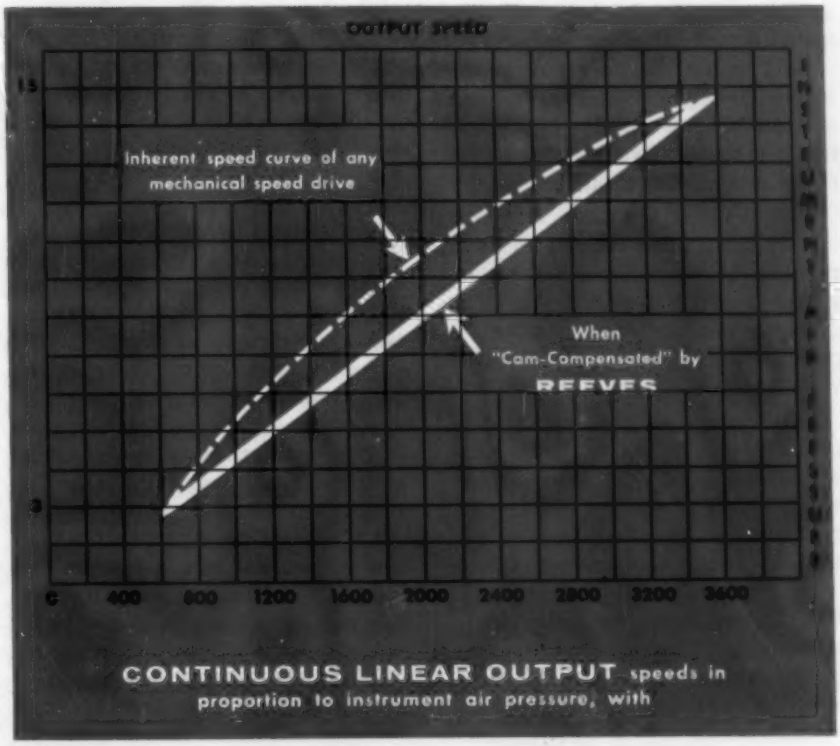

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uals. Many of the very best of these ideas have come from one man or a few men employed by the small highly-specialized company rather than from the large corps of engineers and research scientists maintained by the so-called industrial giant.

So I would like to rephrase my topic this way: "What effect does automation have and will it have in altering the circumstances that favor or threaten small business?"

And, I think the answer to this is that small business can and will prosper in an automation world, if it is careful to pick its field of operations or gradually tailor its present operations to deal with visible trends.

While many of the larger companies already have large and competent staffs of technicians studying, devising, and recommending automation programs, smaller companies cannot afford the luxury of such departments. But they do enjoy one conspicuous advantage. The growing number of companies that are in the business of producing automation equipment naturally are interested in large-volume markets, as is everyone else. A quick look at the census of manufacturers tells any such supplier that if he is looking for volume, the number of plants with less than 1000 employees is where the volume market lies. His urge, therefore, will be to design his wares, in so far as possible, to fit the needs of these more numerous small businesses.

Management Responsibilities

There are businessmen who say they are a part of the American risk enterprise system without seriously believing it. Their strong inclination is to take as much risk out of the business as they can. In this extraordinary period of innovation, no company, large or small, can consider itself beyond the reach of competitors who have new ideas and the determination and skill to make them effective. I do not think there ever will be or should be an entrenched and unassailable position in any industry. I suggest that this flow of competitive innovation, as represented by automation of various kinds, is the surest way to competitive health. Granted it causes adjustments and presents challenges, but I am concerned with those who rather than encouraging the trend and learning how to live with it, are searching for ways to put the brakes on it. I therefore feel that the rise of automation carries with it a heightening of risk, and in a special sense, for the small business.

This leads me to raise this question for the operators of small businesses, "Are you sure you know just where your most serious competitive threats lie?"

The small company supplying the large manufacturer lives in dread of the customer going into his own production of the item. That means a customer is lost. On the other hand, a company which has 500 customers and wakes up some morning to discover that one of his competitors has found the means to supply the market at a considerably lower price, is in danger of losing not just one customer, but the bulk of his business.

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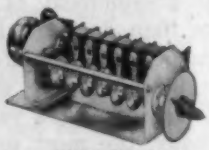

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So, I say that we must take into account that a forward-looking automation program can enable a company — almost overnight — to cause an upheaval in its competitive field—despite the fact that all of its competitors are employing heavy sales artillery.

All business today must be alert to this threat. Moreover, I believe that the handling of this problem cannot be effectively delegated within an organization, on the supposition that it is chiefly a matter of technology.

The important ponderables are precisely those which the owners or directors and top management always hold in their own hands. I refer to the currents and cross-currents of major strategy—the positioning of the company in its own industry, the quandary whether to diversify or to concentrate, the development and use of company cash and credit resources, the handling of depreciation and taxes, and the decision as to the type of personnel that the company's future requires. These are top management considerations, and will always be.

This being so, we must place a new interpretation on the word "research," as it applies to the long-term fortunes of the company, small or large. Today management is being forced to a much more active program of inquiry into all the elements that affect a company's growth or its survival.

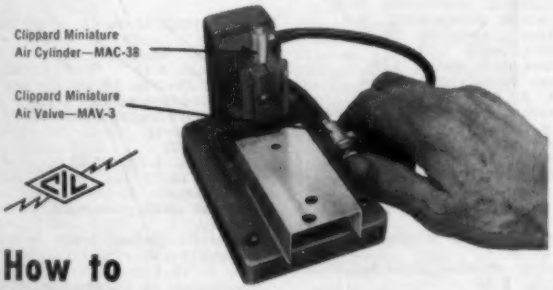
What To Do?

Some of you may say, "I want to take advantage of automation, but what do I do?" First, I feel we make a mistake if we think of it as something new. The search for productive improvements has been going on for years; and each of you, undoubtedly, is doing a lot in your own plants. Second, at the risk of sounding trite, I would suggest the visitation of plants in comparable industries, the use of consultants, the application of incentives within the organizations for improved methods work, and the study of articles in magazines and trade papers on the subject.

What we need most in dealing with the potentialities of automation is a willingness to face the facts and to go through the hard mental labor of solving the necessary equations in terms of each individual company's strengths, weaknesses, ambitions, and bankroll.

So, do not be dissuaded by the half-truths about automation. It is an evolutionary, and not a revolutionary, development. And I am sure that while the small businessman may rarely hit the front pages with his examples of effective automation, he will reap the rewards of a more efficient operation, lower production costs, and greater possibilities for profit—if he is willing to face up to the changes that are taking place, and to make the most of them.

From an address entitled, "Automatic Production and the Small Business Man" presented at the Symposium on Electronics and Automatic Production of Stanford Research Institute and the National Industrial Conference Board, San Francisco, Aug. 1955.



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Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Components

MAGNETICALLY OPERATED FLOAT SWITCH

An iron core positioned by a float influences the path of flux flow of a bar magnet. Position of the float thus determines the magnetic force acting on electrical switching members in a hermetically sealed chamber. Patent 2,726,296 by Louis P. Hanson and Howard H. Suskin.

AUTOMATIC SOURCE SELECTOR VALVE

Separate fluid pressure sources are connected to opposite ends of a piston chamber so that the piston shifts to seats at either end depending upon which pressure predominates. Patent 2,729,226 by David W. Jones, assigned to Kenyon Instrument Co.

MEANS FOR REJECTING SPURIOUS FLOWMETER SIGNALS

Improved flowmeter design includes two pairs of sensing electrodes spaced around a probing section on a flow tube oriented in the gap in a magnet core. Patent 2,722,122 by Arthur R. Soffel, assigned to Vitro Corp. of America.

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Data Processing

MAGNETIC INFORMATION-STORING DEVICE

Stored information is retrieved by equipment including several sheet-like record members, a magnetic drum, magnetic heads and a signal reproducer, and means to position the drum and one of the record members for a magnetic transducing operation by any of the heads. Patent 2,722,676 by Semi J. Begun, assigned to Clevite Corp.

METHOD AND MEANS FOR DUPLICATING MAGNETIC RECORDS BY MAGNETIC TRANSFER PHENOMENON

Recorded data is transferred from a magnetized master record tape to several copy tapes coincidently by use of a plurality of air core transfer solenoids. Patent 2,723,315 by Hugh A. Howell, assigned to the Indiana Steel Products Co.

Handling

CONVEYOR CONTROL SYSTEM

Package dispatching system includes a main conveyor and several distribution conveyors. Controls set at the loading station of the main conveyor selectively actuate displacement means feeding each distribution conveyor. Patent 2,728,466 by William R. Postlewaite, Herbert Rogers Jr. and Richard H. Long, assigned to California Research Corp.

MAGNETIC SHEET TRANSFER DEVICE

Magnetizable articles are transferred from a primary to an auxiliary conveyor in time with said conveyors by means of rails which are alternately magnetically energized and de-energized. Patent 2,726,752 by William W. Maher, assigned to American Can Co.

BOTTLE HANDLING APPARATUS

Bottles aligned on two conveyors are introduced into a case which is positioned on a conveyor beneath the bottle conveyors. Patent 2,722,354 by Leslie A. Mapes.

• • •

Machines

ELECTROSTATIC COATING APPARATUS

Unwanted coating of conveyor carrying workpieces through an electrostatic coating zone is prevented by a permanent sheath of insulating material on which an electrical surface charge is impressed. Patent 2,729,191 by Edwin M. Ransburg, assigned to Ransburg Electro-Coating Corp.

HIGH-SPEED MOTOR-DRIVEN LATHE AND TEMPERATURE CONTROL MEANS

To control driving belt tension and motor temperature, the driving motor is pivotally supported on one side and adjustably supported on the other side by a hydraulic piston, and a fan is mounted on the motor shaft. Patent 2,725,775 by Lorenz A. Leifer, assigned to Gisholt Machine Co.

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Process Design

LIQUID THERMAL DIFFUSION METHOD

Liquid mixture of two dissimilar materials is continuously separated into fractions enriched in each of the materials by passing a shallow stream of the mixture at a given rate between parallel walls with a temperature gradient maintained across the stream. Patent 2,723,033 by Arthur L. Jones and Philip S. Fay, assigned to the Standard Oil Co.

ALUMINUM COATING

Aluminum articles can be formed by depositing aluminum on a conductive base in an electrochemical plating type operation and then separating the base from the aluminum coating. Patent 2,728,718 by William C. Schickner, assigned to the Battelle Development Corp.

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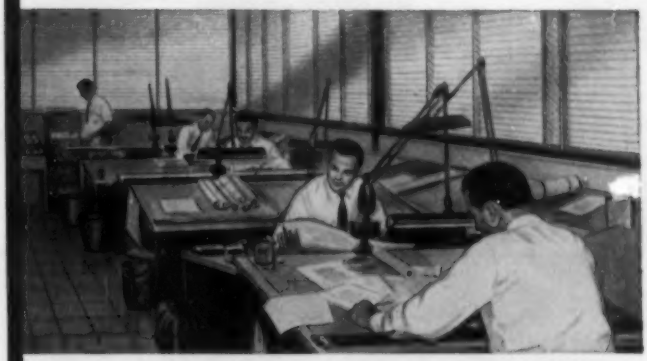

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By H. C. Town, Head of the Engineering Department, Keighley Technical College; 192 *pages,* 5¾ *by* 8¾ *inches, illustrated, clothbound, published by Philosophical Library, New York; available from* AUTOMATION; $7.50 *postpaid.*

First section of this book describes advantages and limitations of oil for power transmission. Main types of pumps and valves are illustrated and discussed. Circuit diagrams and applications to various types of machines are explained. Separate chapters are included on hydraulic rotary drives and hydrokinetic transmission. The second section of the book discusses features of pneumatic power uses. Air compressors, pneumatic tools and air-operated jigs and fixtures are covered in addition to illustrations of various industrial applications. Subject of the concluding chapter is the combination of hydraulic and pneumatic power elements.

INFORMATION PROCESSING EQUIPMENT

Edited by M. P. Doss, Research and Technical Dept., The Texas Co.; 270 *pages,* 6 *by* 9 *inches, illustrated, clothbound, published by Reinhold Publishing Corp., New York; available from* AUTOMATION; $8.75 *postpaid.*

This book does not cover all makes of equipment but indicates types which may assist a reader in meeting certain requirements. Text material is based on papers presented at the September, 1953 meeting of the American Chemical Society in Chicago. Some of the subjects covered are audio methods for handling data, storing and finding information on punched cards, and numerical data-handling machines.

DYNAMICS OF MACHINERY

By A. R. Holowenko, associate professor of mechanical engineering, Purdue University; 464 *pages,* 5¾ *by* 9 *inches, illustrated, clothbound, published by John Wiley & Sons Inc., New York; available from* AUTOMATION; $7.50 *postpaid.*

With higher and higher machine speeds, increased attention to dynamic aspects of machine design is required. This book is concerned with kinematics and force analysis but not with material selection or proportioning of parts. Use of free body diagrams is emphasized and step-by-step developments are shown to illustrate their use.

FEEDBACK CONTROL SYSTEMS

By Gilbert H. Fett, professor of electrical engineering, University of Illinois; 361 *pages,* 5½ *by* 8½ *inches, illustrated, clothbound, published by Prentice-Hall Inc., New York; available from* AUTOMATION; $10.00 *postpaid.*

This book is written for practicing engineers in industry and advanced engineering students who wish to get a basic understanding of feedback control systems and the tools and techniques required to solve problems in this field. After an introduction to control devices and components of feedback control systems, the author discusses solutions of system equations, Nyquist criterion for stability, and analysis and synthesis of complex and nonlinear systems.

Association Publications

OPERATIONS RESEARCH CONFERENCE PROCEEDINGS

Looseleaf, 144 *pages,* 8½ *by* 11 *inches; available from Society for Advancement of Management,* 74 *Fifth Ave., New York* 11, *N. Y.;* $10.00.

In September 1955 a conference was held by the SAM which is recorded in this volume. Meaning, history, future, purposes and techniques of operations research are discussed. Names of several companies using OR are listed and a survey of OR plans for 310 companies is reported. Details of a warehousing and inventory study are included as well as cases on optimum reserve generating capacity and optimum allocation of sales effort.

SCIENTIFIC APPARATUS MAKERS ASSOCIATION TENTATIVE STANDARDS

Looseleaf, 21 *pages,* 8½ *by* 11 *inches, illustrated; available from Scientific Apparatus Makers Association, Recorder-Controller Section,* 522 *Fifth Ave., New York* 36, *N. Y.; Free.*

SAMA Standards RC4,5,6,7 and 8, bearing the suffix 10-1955, cover the following tentative standards: Bimetallic Thermometers, Resistance Thermometers, Filled System Thermometers, Glass Stem Industrial Thermometers and Thermocouple Thermometers (Pyrometers). These tentative standards approved in October 1955 will become SAMA industry standards after two years elapse.